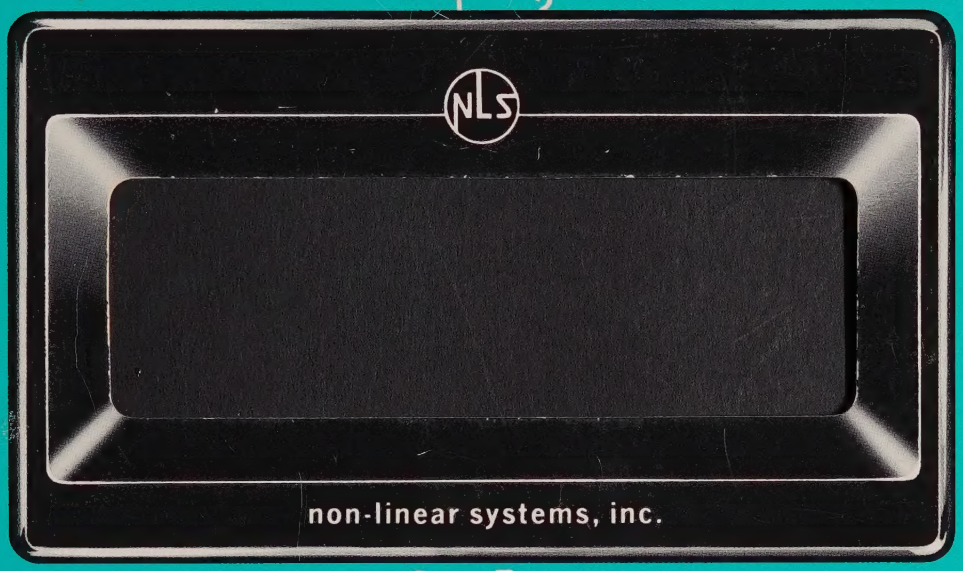

non linear systems, inc.

DEL MAR, CALIFORNIA

ORIGINATOR-DIGITAL VOLTMETER

MODEL NO. X2

SERIAL NO. X2,50

FINAL TEST BY:

ACCEPTED BY:

NLS 84 105

NLS 6

non-linear systems, inc.
del mar, california

QUALITY ASSURANCE SINCE 1952

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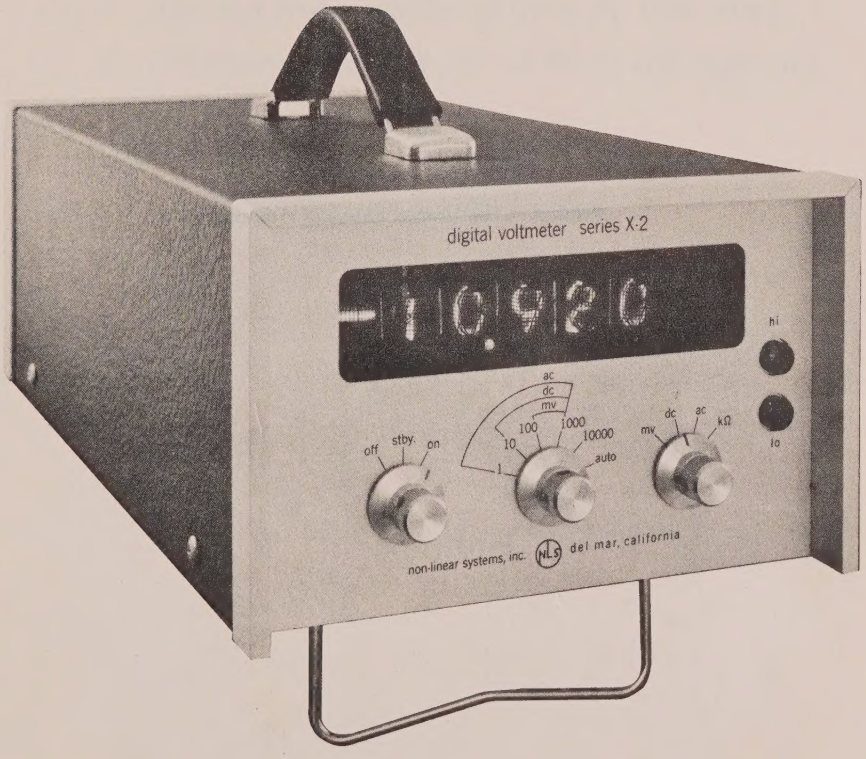
March 1967
Revised April 1967

INSTRUCTION MANUAL

SERIES X-2

DIGITAL VOLTMETER

#110-055



Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR, CALIFORNIA

Printed in the United States of America

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ERRATA

Decade Assembly Schematic - 37-30

1. Change Q2 to 2N697
2. Remove R3 and wire from collector of Q2 to pin 1 of B5440.
3. Add wire from collector of Q2 to pin 14 of B5440.
4. R17 remains between pin 1 of B5440 and +200V line.

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CHAPTER I

INTRODUCTION AND SPECIFICATIONS

The NLS Series X-2 Digital Voltmeter is a three-range, four-digit instrument with automatic polarity and with provisions for 20% over-ranging on the two lowest ranges. An automatic ranging feature is offered as an option. The instrument may be used as a bench model or, with the use of rack-mounting adapters, may be rack-mounted in a standard 19-inch mounting rack.

OPTIONAL FUNCTION ACCESSORIES

In addition to measuring DC voltages, the Series X-2 DVM is capable of measuring AC voltages, millivolts and ohms. These extra features may be obtained by utilizing optional plug-in modules. A K Ohms converter/pre-amplifier provides ohms and millivolt measurements and one of two types of AC converters (50 Hz to 10K Hz or 50K Hz to 100K Hz) provides AC voltage measurement.

GENERAL

The Series X-2 Digital Voltmeters are solid state integrating instruments that measure the absolute value of DC voltages or the integral of varying voltages. In these instruments the unknown input voltage is converted to a pulse train whose repitition rate is directly proportional to input voltage magnitude. The total number of pulses generated over a clocked 0.1 second interval is counted electronically and displayed as the voltage value.

OPERATING PRINCIPLE

An input of 10 volts to the instrument creates 10,000 pulses in 0.1 second; this is displayed as 10.000 volts. If the input voltage changes during the measuring interval, the pulse repetition rate changes proportionately, and the total number of pulses that occurs during the 0.1 second sample period is a measure of the number of volt-seconds at the input. Since these instruments mathematically integrate the input voltage, they are useful for obtaining the velocity from a voltage which is proportional to acceleration. In addition, these instruments are inherently able to reject sinusoidal ripple because the integrated value of an integral number of sine waves is zero. Therefore if an integral number of cycles of sine wave noise occurs during the 0.1-second sampling interval, its contribution to the overall reading is "integrated out".

STABILITY

Long-term stability and reliability are assured in part because no vacuum tubes are used in this instrument. Therefore, the problems associated with changing emission levels and with heating are eliminated. The whole instrument dissipates only about 25 watts and a ventilating fan is not required.

FLOATING INPUT

Because input signal leads may be disconnected from the Series X-2's outer chassis (by removing a shorting strap between J5 and J6 on the rear of the instrument), signal-to-chassis potentials up to 500 volts are permissible. Floating input adds to the DVM's versatility by permitting it to measure voltage sources which could not be accurately measured by a non-isolated meter.

COMMON MODE REJECTION

Rejection of common-mode signals, those

caused by AC or DC currents flowing between signal source ground and instrument chassis ground is a feature of the Series X-2 DVM. (To obtain CMR, the shorting strap described in the above paragraph must be removed.) Common-mode signal rejection is important in a wide range of applications - testing complex electrical and electronic systems, in automatic measuring systems, and measuring outputs from thermocouples, strain gages and other transducers where common-mode signals may be many times greater than the measured DC voltage.

PROCEDURE TO DETERMINE CMR

1. Turn the X-2 DVM on and allow 30 minutes for warm-up.

2. Remove shorting strap between J5 and J6.

3. Connect DVM to signal source and common-mode source as shown in Figure 1-1. Signal source is preferably a series string of three or four 1.5V batteries (flashlight cells or 1.3V mercury cells). To obtain an accurate measurement of CMR, the source resistance of the signal source should be less than 10 ohms. The output of a variac, connected as shown in Figure 1-1, will adequately provide the required common-mode source.

4. Set variac to zero volts then advance variac in voltage until a one digit "bobble" is observed in the least significant decade then, back off variac until "bobble" just stops. Measure the variac output with an AC voltmeter and convert to peak-to-peak voltage.

5. To obtain rejection ratio, divide peak-to-peak common voltage by 1 MV.

$$\text{Common-mode rejection radio} = \frac{E_{p-p}}{10^{-3}}$$

$$DB = 20 \log \frac{E_{p-p}}{10^{-3}}$$

$$DB = 20 \log 1,000\ E_{p-p}$$

6. For example, if the common-mode voltage is 3.5V

$$E_{p-p} = 3.5 \times 2.828$$

$$E_{p-p} = 10V \text{ and}$$

$$DB = 20 \log 1,000 \times 10$$

$$DB = 20 \log 10^{4}$$

$$DB = 20 \times 4 = 80$$

Common-mode rejection = 80 DB

The NLS Sales Representative or Engineering Department will be pleased to assist you with specific application problems and, of course, will gladly welcome your comments and suggestions.

SPECIFICATIONS

CIRCUITRY:	All solid state.
ANALOG-TO-DIGITAL CONVERSION:	Bi-polar integrator.
FULL SCALE DC RANGES:	±9.999, ±99.99, ±999.9 with 20% over-range on the two lower ranges.

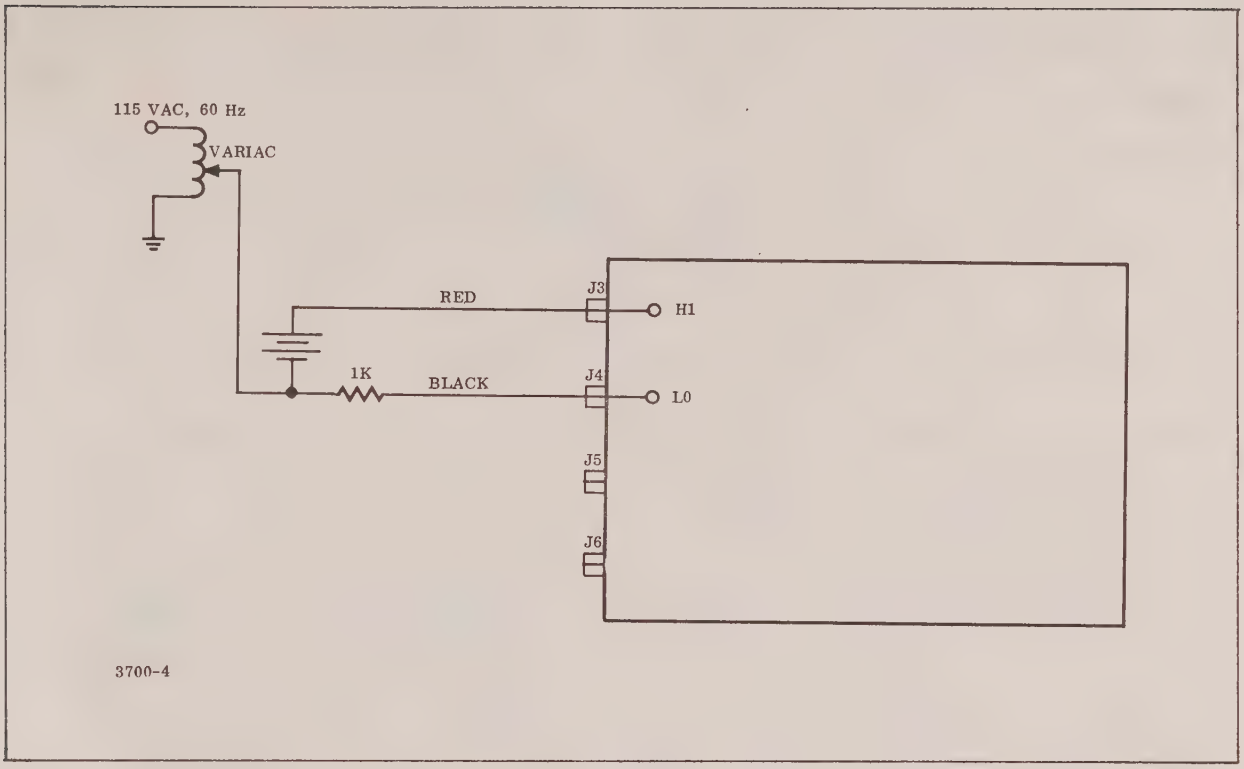


Figure 1-1. Connections to Determine CMR

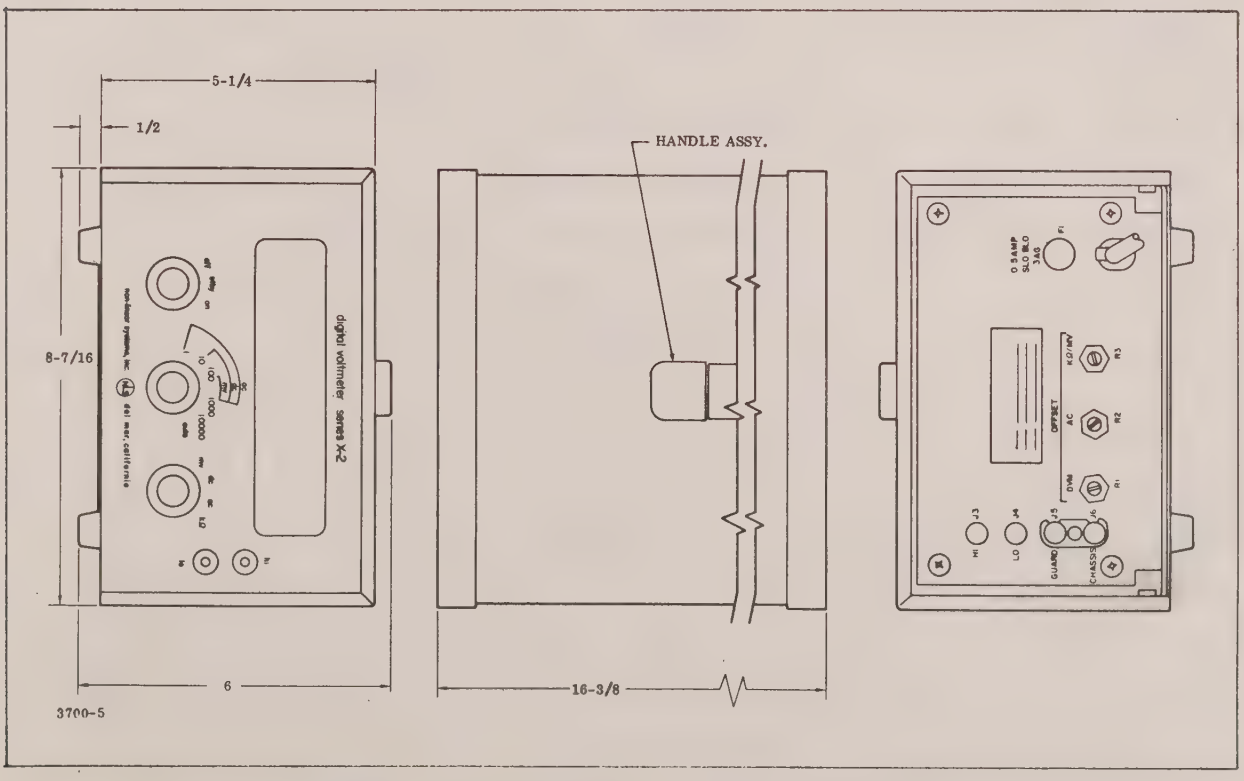


Figure 1-2. Series X-2 DVM Outline Drawing

ACCURACY AT ASA REFERENCE CONDITIONS:	±0. 01% of full scale ±0. 02% of reading.
RESOLUTION:	One digit.
RESPONSE TIMES:	Voltage-to-Frequency Converter Settling Time - 100 MS (with filter). Digitizing Time - 100 MS. Range Selection Time - 100 MS.
INPUT RESISTANCE:	10 megohms, constant all ranges, except when 20% over-range is exceeded.
COMMON MODE REJECTION:	100 DB @ DC; 80 DB @ 60 Hz +- 1KΩ unbalance
RANGE SELECTION:	Manual or Automatic/Manual (see options).
POLARITY SELECTION:	Automatic.
INPUT CONNECTIONS:	Front and rear. Input may be floated ±500 volts above chassis by removing shorting strap from rear input connectors.
AMBIENT TEMPERATURE:	Extreme - 12^{o} C to 50^{o}C.
POWER REQUIREMENTS:	105/125 VAC, 50/60 Hz.
MOUNTING POSITION:	Any.
WEIGHT:	12 pounds
SIZE:	5-1/4 inches (excluding feet and handle) x 8-7/16 inches x 16-3/8 inches.
OPTIONS AVAILABLE:	Automatic ranging.
ACCESSORIES AVAILABLE:	AC/DC Converters. K Ohms/DC Converter and Pre-Amplifier. Rack-Mounting Adapter.

AC/DC Converter, Types I and II for X-2

RANGES; including 20% over-range	1. 1999/11. 999 119. 99 & 500. 00 VAC
FREQUENCY RESPONSE	10K Hz 100K Hz Lower frequency converters are available on special order. The 10K Hz converter is usable to 30K Hz in the manual ranging mode

ACCURACY: 10K Hz	0.05% reading or 0.02% FS, 200 Hz to 3K Hz 0.1% reading & 0.05% FS, 50 Hz to 200 Hz and 3K Hz to 10K Hz. 30 Hz accuracy is typically 0.3%	
100K Hz	Same as 10K Hz, plus: 0.3% reading and 0.1% FS, 10K Hz to 30K Hz, 500 VAC 0.5% reading and 0.1% FS, 30K Hz to 100K Hz, 150 VAC	
RESPONSE TIME	600 milliseconds to 0.1% of final value	
INPUT IMPEDANCE	One megohm, shunted by 100 PF	
RANGING	Automatic and manual	

Ohms/DC Converter

ACCURACY	Four Digit	Maximum Current
±0.01% FS and ±0.02% reading (1KΩ, 10KΩ, 100KΩ and 1000KΩ ranges)	1.1999KΩ	10 MA
	11.999KΩ	1 MA
	119.99KΩ	100 μA
	1199.9KΩ	10 μA
±0.01% FS ±0.1%	11,999.KΩ	1 μA
STABILITY	0.05% full scale for at least 90 days on all ranges	
RESPONSE TIME	100 milliseconds for step response. 200 milliseconds for step response with range change. 700 milliseconds on 10 megohm range	
RANGING	Automatic and manual (Manual only 10,000K Range)	
INPUT CONFIGURATION	Two wire with voltage protection	

Automatic Ranging DC Preamplifier

RANGES	X10	±000.1 MV to ±1199.9 MV
	X100	±00.01 MV to ± 119.99 MV
ACCURACY	X10	±0.02% reading and ±0.01% Full Scale
	X100	±0.05% reading and ±0.05% Full Scale
GAIN STABILITY	0.01% for at least 30 days	
ZERO STABILITY	Drift does not exceed ±50μV or ±5 digits, whichever is greater, for at least seven days at constant temperature.	
INPUT IMPEDANCE	Greater than 100 megohms	
RESPONSE TIME	500 MS for step response to 0.01%	

Specifications are Subject to Change Without Notice

CHAPTER II

INSTALLATION AND OPERATION

UNPACKING

The instrument is shipped in a heavy cardboard container. Cut the tape on the top of the container and open. If damage is seen, promptly notify the carrier.

MOUNTING

The instrument was primarily designed as a bench instrument, however, two types of mounting adapters for mounting in a standard 19-inch mounting rack are available at customer's option. One type contains an additional drawer for storage of tools, spare parts, etc; the other type will accommodate two Series X-2 DVM's.

CAUTION

Do not operate the instrument before removing the cover and ensuring that each plug-in board is firmly in place. See Initial Preparation, DC Voltage Calibration in Chapter III for instructions on cover removal.

POWER SOURCE

The instrument requires a 115-volt, 50-60 Hz, single-phase power source for operation.

FUSING

The instrument is protected by a 3AG one-half ampere slo-blo fuse which is located in an extractor post on the rear panel.

POWER GROUNDING

The third pin of the power plug grounds the outer chassis of the instrument (Figure 2-1).

CONNECTORS

Two input connectors (J1 and J2, labeled HI and LO respectively) are located on the front panel of the instrument (Figure 2-2) and are wired in parallel with two connectors (J3 and J4) located on the rear of the instrument (Figure 2-3). Two additional connectors (J5 and J6) are located on the rear of the unit and under normal operating conditions are connected together with

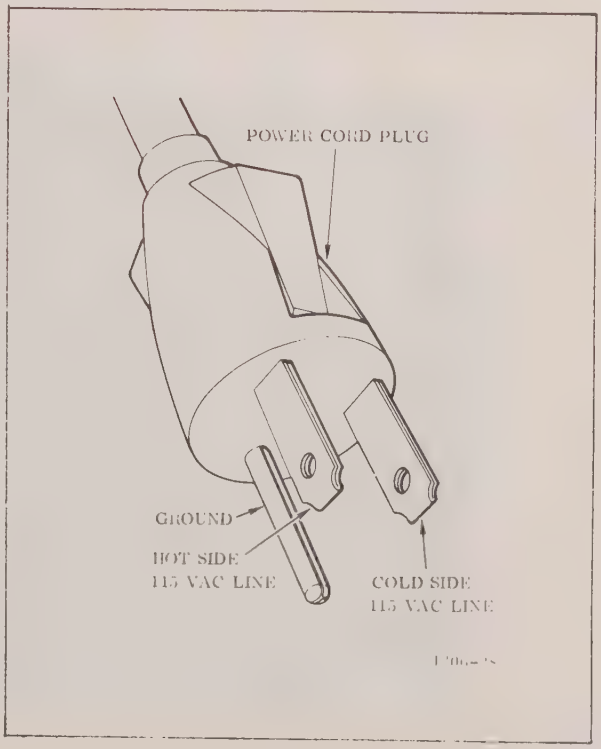


Figure 2-1. Power Plug Pin Coding

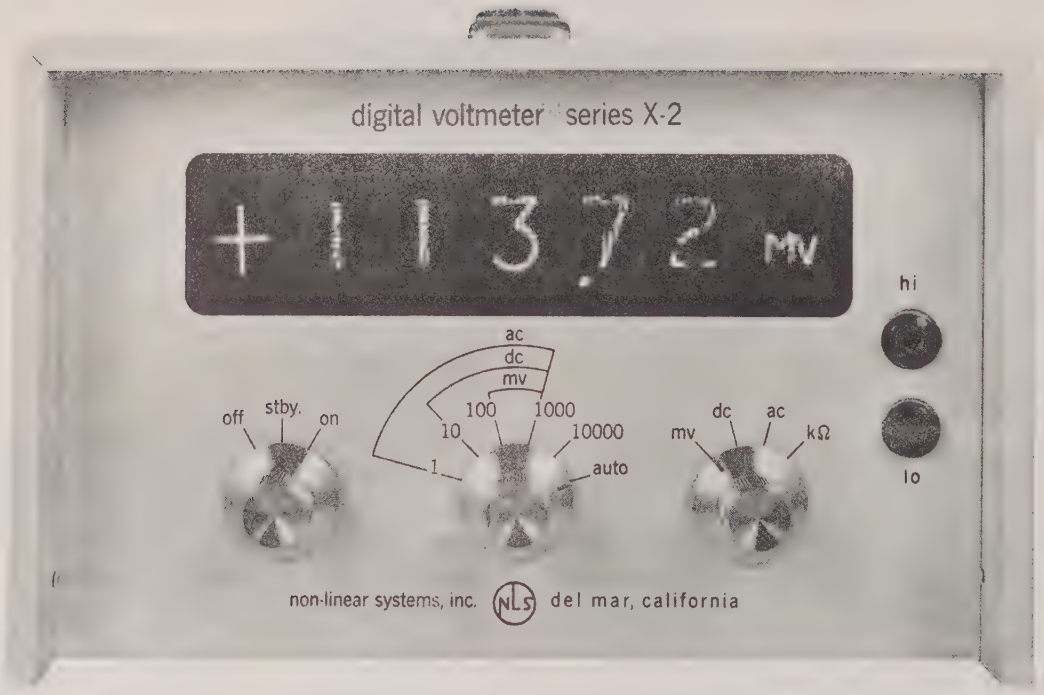


Figure 2-2. Front View

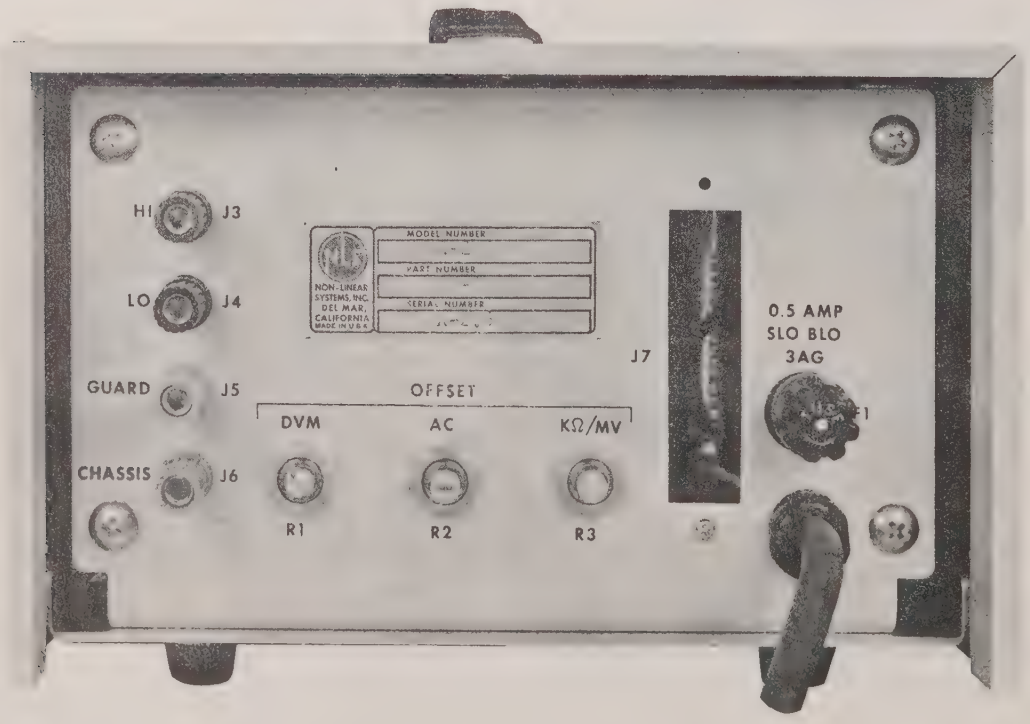


Figure 2-3. Rear View

a shorting strap. To float the input above chassis ground (up to ±500 volts), the shorting strap must be removed.

CABLE CONNECTIONS

The instrument is supplied with an input cable (P/N 2BC-AL-36). See Figure 2-4 for connection information.

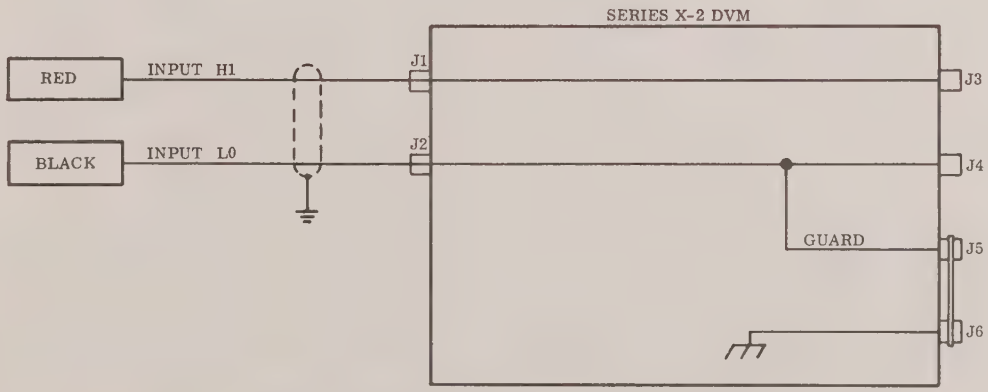
CONTROLS

POWER SWITCH

The power switch is located on the front panel of the instrument and has three positions (OFF, STBY. AND ON). The STBY. position is used to stop the instrument from taking further readings. The ON position commands the instrument to take readings at its maximum rate (allow 30 minutes for instrument warm-up).

RANGE SWITCH

The range switch is located on the front panel of the instrument and has six positions. (See Table I.) When in the 1 position, the instrument is locked in the 1 volt range for the measurement of AC voltages or in the 1K range for the measurement of K ohms. When in the 10 position, the instrument is locked in the 10-volt range for the measurement of AC or DC voltages or in the 10K range for the measurement of K ohms. When in the 100 position, the instrument is locked in the 100-volt range for the measurement of AC and DC voltages, in the 100 MV range for the measurement of millivolts or in the 100K range for the measurement of K ohms. When in the 1000 position, the instrument is locked in the 1000-volt range for the measurement of AC and DC voltages, in the 1000 MV range for the measurement of millivolts or in the 1000KΩ range for the measurement of K ohms. When in the 10000 position, the instrument is locked in the 10,000 KΩ range for



TO FLOAT INPUT ABOVE CHASSIS (UP TO ±500 VOLTS), REMOVE SHORTING STRAP BETWEEN CONNECTORS J5 AND J6.

3700-1

Figure 2-4. Input Connections

Table I. Measurement Capabilities

Function Switch Positions	Range Switch Positions: 1	10	100	1000	10000	AUTO
MV	☒	☒	100 MV RANGE	1000 MV RANGE	☒	100 MV or 1000 MV RANGES
DC	☒	10 VDC RANGE	100 VDC RANGE	1000 VDC RANGE	☒	10 VDC, 100 VDC, or 1000 VDC RANGES
AC	1 VAC RANGE	10 VAC RANGE	100 VAC RANGE	1000 VAC RANGE (500 VAC MAX.)	☒	1 VAC, 10 VAC 100 VAC or 1000 VAC RANGES (500 VAC Max)
KΩ	1KΩ RANGE	10KΩ RANGE	100KΩ RANGE	1000KΩ RANGE	10,000KΩ RANGE	ALL EXCEPT 10,000KΩ RNG.

NOTE

The combined positions of the range and function switches as indicated by ☒ above will produce erroneous readings.

the measurement of K ohms. If the instrument has the automatic ranging capability, the proper range is automatically selected when the switch in in the AUTO position. (The 10,000 KΩ range can only be selected manually.) With the switch in the AUTO position (if the instrument does not have the auto-ranging capability), the readout will not display decimals and the instrument will be in the lowest range of the particular function selected by the function switch.

FUNCTION SWITCH

The function switch is located on the front panel of the instrument and has four positions. (See Table I.) It is used to select the desired measurement funtion, either MV, DC, AC or KΩ.

OFFSET CONTROLS

Three screwdriver-adjust potentiometers are located on the rear of the unit. They are provided to zero the reading of the instrument in each of its measuring functions. The specific use of these controls is described in the calibration instructions.

CHAPTER III

CALIBRATION

In the calibration instructions provided in this chapter, it is assumed that the instrument is in good working order and only requires calibration. If any components are defective, it may be difficult, if not impossible, to calibrate the instrument.

SCOPE

The basic DC calibration procedure is divided into six distinct areas: reference adjustment; zero offset adjustment; 10-volt range calibration for a positive input; 10-volt range calibration for a negative input; 100-volt range calibration; and 1000-volt range calibration.

Since the Series X-2 instruments are capable of millivolts, AC and ohms measurements, calibration procedures for these functions are also included.

DC VOLTAGE CALIBRATION

EQUIPMENT REQUIRED

1. A voltmeter capable of measuring -20 VDC (±1 MVDC).
2. An extension board, NLS No. 1009-41.
3. A voltage standard between 9.000 volts and 11.998 volts.
4. A voltage standard between 90.00 volts and 119.98 volts.
5. A voltage standard between 900.0 volts and 1000.0 volts.

NOTE

It should be noted that the error in making a measurement with the Series X-2 DVM can be as much as the stated accuracy of the instrument plus the accuracy of the voltage standards used in its calibration.

INITIAL PREPARATION

1. Remove the cover of the instrument by removing the four screws (two on each side) attaching the cover to the chassis (Figure 3-1).
2. Plug the power cord into a 115 VAC, 50-60 Hz, single phase power source.
3. Place the power switch in the STBY. position and allow 30 minutes for instrument warm-up.

PROCEDURE

Reference Adjustment

1. Remove the reference assembly, P/N 37-36, from instrument (Figure 3-2).
2. Insert extension board into J12 main board assembly.
3. Mount reference assembly on top of extension board by inserting reference board pins into extension board. Use care to ensure proper pin alignment.
4. Connect a voltmeter capable of measuring -20 VDC (±1 MVDC) between ground and -20V output, pin 33 and pin 39 (Figure 3-3).
5. Adjust R1 (Figure 3-3) on reference assembly until test meter reads -20V (±1 MVDC).

6. Remove reference assembly from extension board and remove extension board from instrument.

7. Insert reference assembly into J12.

Zero Offset Adjustment

1. Place function switch in the DC position.

2. Place power switch in the ON position.

3. Place range switch in the 10 position.

4. Connect the red and black clips of the DVM input cable together.

5. Rotate the DVM OFFSET potentiometer R1, located on the rear of the instrument, to a position which causes the readout to display ±0.000 DC.

10-Volt Range Calibration for a Positive Input Voltage

1. Connect the black lead of the DVM input cable to the negative terminal of the voltage standard described in paragraph 3 under Equipment Required. Connect the red lead to the positive terminal.

2. Apply approximately 9.5 volts.

3. The numerical value displayed in the readout should be equal to the voltage of the voltage standard. If it is not, adjust potentiometer R30 (Figure 3-2) of the Attenuator Assembly, P/N 37-39, until the readout displays the correct value. Note that input impedance of DVM is 10 Megohms.

NOTE

Potentiometers R31 and R38 (Figure 3-2) have been adjusted and sealed at the factory and must not be adjusted in the field. They are temperature coefficient compensators for the ± prime calibration.

Figure 3-1. Cover Removal

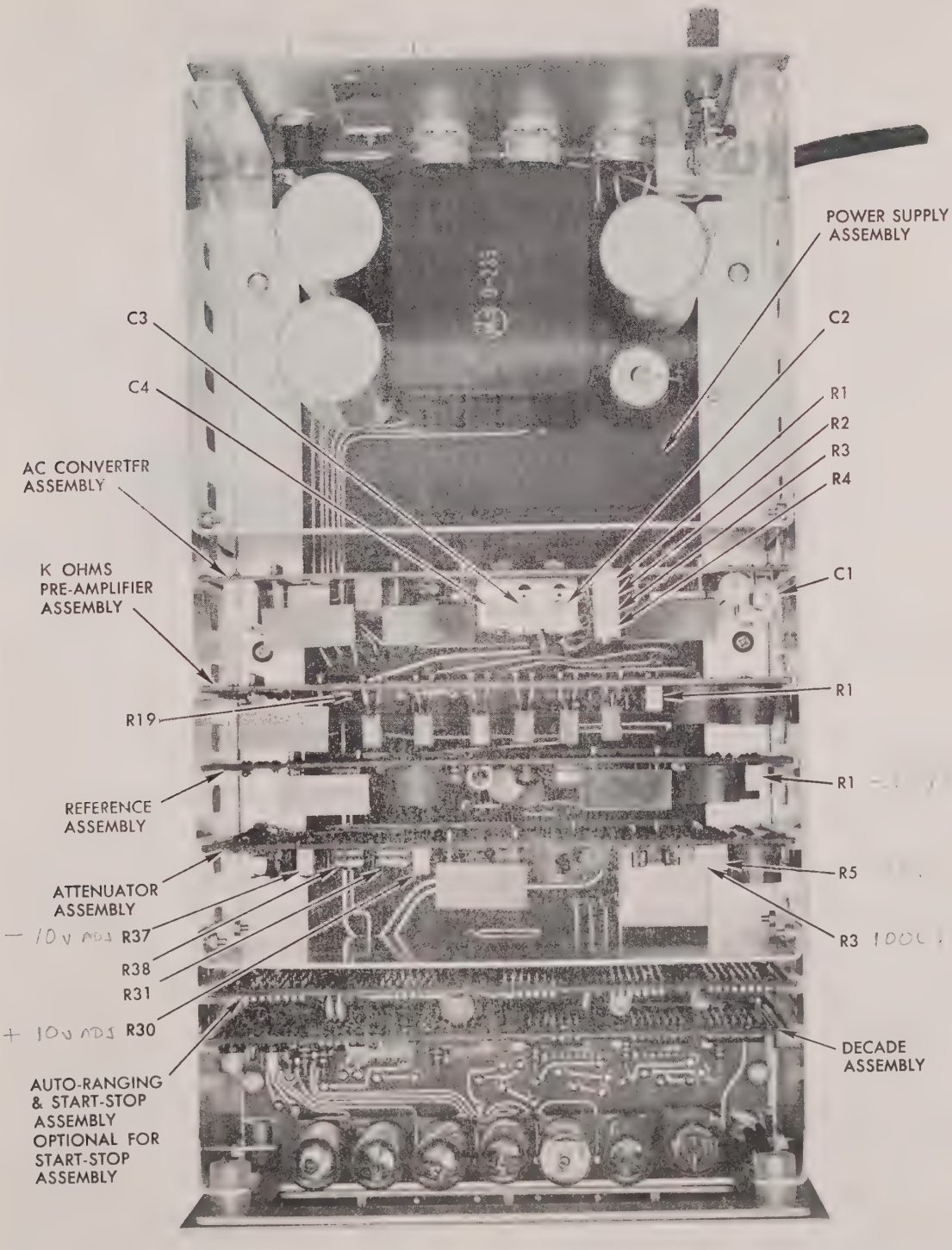


Figure 3-2. Location of Major Subassemblies and Adjustment Points

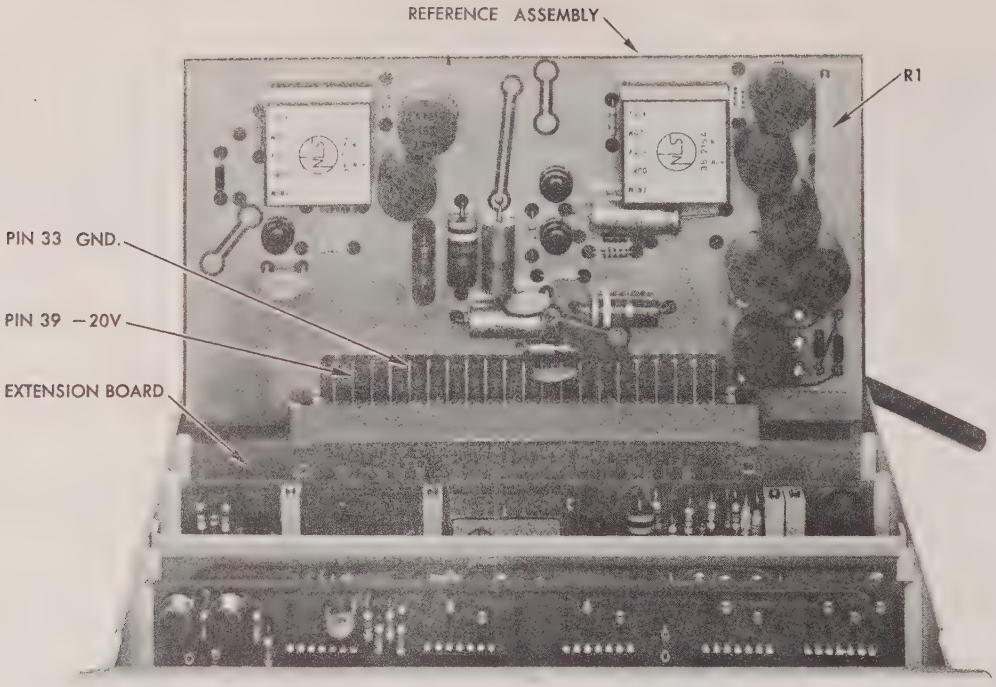


Figure 3-3. Reference Adjustment

10-Volt Range Calibration for a Negative Input Voltage

1. Reverse the connections to the voltage standard.

2. Apply approximately 9. 5 volts.

3. The numerical value displayed in the readout should be equal to the voltage of the voltage standard. If it is not, adjust potentiometer R37 (Figure 3-2) of the Attenuator Assembly until the readout displays the correct value.

WARNING

Use extreme caution in performing the following steps as dangerously high voltages will be employed.

100-Volt Range Calibration

1. Place the range switch in 100 position.

2. Connect the black lead of the DVM input cable to the negative terminal of the voltage standard described in paragraph 4 under Equipment Required. Connect the red lead to the positive terminal.

3. Apply approximately 95 volts.

4. The numerical value displayed in the readout should be equal to the voltage of the voltage standard. If it is not, adjust potentiometer R5 (Figure 3-2) of the Attenuator Assembly until the readout displays the correct value.

WARNING

Use extreme caution in performing the following steps as dangerously high voltages will be employed.

1000-Volt Range Calibration

1. Place the range switch in the 1000 position.
2. Connect the black lead of the DVM input cable to the negative terminal of the voltage standard described in paragraph 5 under Equipment Required. Connect the red lead to the positive terminal.
3. Apply approximately 950 volts.
4. The numerical value displayed in the readout should be equal to the voltage standard. If it is not, adjust potentiometer R3 (Figure 3-2) of the Attenuator Assembly until the readout displays the correct value.

AC CONVERTER CALIBRATION

ADDITIONAL EQUIPMENT REQUIRED

1. An Audio Voltage Standard between 1 volt, 200 Hz - 10K Hz and 500 volts, 200 Hz - 10K Hz.

INITIAL PREPARATION

1. Ensure that the instrument is properly calibrated in the DC voltage measurement function and ensure a 30-minute warm-up period.

PROCEDURE

1. Place the function switch in the AC position.
2. Place the range switch in the 1000 position.
3. Place the power switch in the ON position.
4. Connect the red and black clips of the DVM input cable together.
5. Rotate the AC OFFSET potentiometer. R2, located on the rear of the instrument, to a position which causes the readout to display 0.000 AC.

WARNING

Use extreme caution in performing the following steps as dangerously high voltages will be employed.

CAUTION

Do not apply more than 500 VAC or damage to the AC Converter Assembly may result.

6. Connect the red lead of the DVM input cable to the AC HI terminal and the black lead to the AC LO terminal of the Audio Voltage Standard.
7. Apply approximately 450.00 volts, 200 Hz and adjust R1 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.
8. Apply approximately 450.00 volts, 10K Hz and adjust C1 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.

WARNING

Use extreme caution in performing the following steps as dangerously high voltage will be employed.

9. Place the range switch in the 100 position. Apply approximately 90.00 volts, 200 Hz and adjust R2 (Figure 3-2) of the AC Converter Assembly until the

numerical value displayed in the readout is equal to the voltage applied.

10. Apply approximately 90.00 volts 10 K Hz and adjust C2 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.

11. Place the range switch in the 10 position. Apply approximately 9.000 volts. 200 Hz and adjust R3 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.

12. Apply approximately 9.000 volts. 10K Hz and adjust C3 of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.

13. Apply approximately 0.9000 volts.200 Hz and adjust R4 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.

14. Apply approximately 0.9000 volts. 10K Hz and adjust C4 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage aplied.

OHMS CONVERTER AND PRE-AMPLIFIER CALIBRATION

ADDITIONAL EQUIPMENT REQUIRED

1. An ohms standard accurate to 0.01%.
2. A voltage standard between 90.00 millivolts and 119.98 millivolts.

INITIAL PREPARATION

1. Ensure that the instrument is properly calibrated in the DC voltage measurement function and ensure a 30-minute warm-up period.

PROCEDURE

1. Place the power switch in the ON position.
2. Place the range switch in the 10000 position.
3. Place the function switch in the KΩ position.
4. Connect the red and black clips of the DVM input cable together.
5. Rotate the KΩ/MV OFFSET R3 potentiometer. located on the rear of the instrument. to a position which causes the readout to display 0000 KΩ.
6. Connect the two leads of the DVM input cable to the two output terminals of the ohms standard.
7. Apply approximately 9000 KΩ and adjust R1 (Figure 3-2) of the Ohms Converter and Pre-amplifier Assembly until the numerical value displayed in the readout is equal to the ohmic value applied.
8. Place the range switch in the 100 position.
9. Place the function switch in the MV position.
10. Connect the red and black clips of the DVM input cable together.
11. Rotate the KΩ/MV OFFSET R3 potentiometer. located on the rear of the instrument. to a position which causes the readout to display 00.00 MV.
12. Connect the black lead of the DVM input cable to the negative terminal of the voltage standard described in paragraph 2 under Additional Equipment Required. Connect the red lead to the

positive terminal.

13. Apply approximately 95.00 millivolts and adjust R19 of the Ohms Converter/ Pre-amplifier Assembly (Figure 3-2) until the numerical value displayed in the readout is equal to the voltage of the voltage standard.

CHAPTER IV

MAINTENANCE

In the Series X-2 Digital Voltmeter, virtually all circuit components are assembled on plug-in modules. Thus maintenance problems are simplified to the point where the instrument can be kept operating without the need for highly trained maintenance personnel. Because of this plug-in design, downtime is held to a minimum; the unit can be kept operating in locations from which it would be impractical or inconvenient to send the instrument to a repair facility or to the manufacturer. Only a very few minutes are needed to replace all the plug-in boards. By using trial-and-error techniques the instrument can be rapidly returned to service, and the defective module repaired at a later date.

For a general understanding of the principles of operation of the Series X-2 DVM, refer to Figures 4-1 through 4-11. For a more detailed analysis, refer to the schematic and wiring diagrams at the end of this manual.

In order to pursue the plug-in philosophy to the fullest, spare modules as listed in Section V, Recommended Spare Parts List, should be kept in stock

If it is desired to measure voltages and check waveforms on a particular plug-in module, a 41-pin extension board will be required to raise the board so that pin contacts become accessible. These boards, NLS part number 1009-41, may be ordered from any NLS representative or from the NLS Main Office in Del Mar, California.

DIGITAL READOUT REPLACEMENT

The readout tubes providing the digital, polarity and function displays have exceedingly long-life expectancy and rarely require replacement. However, to replace a readout tube in the event of failure, perform the following steps:

1. Remove the cover from the instrument by removing the four screws (two on each side) attaching the cover to the chassis.

2. Remove the decade assembly, P/N 37-30, from the instrument (front board).

3. Firmly grasp the decade assembly with one hand and the malfunctioning tube with the other.

4. With a rocking motion, carefully pull the tube from its socket.

5. Install new tube, using care to properly align pins into tube socket, and replace decade board and cover in reverse order of removal.

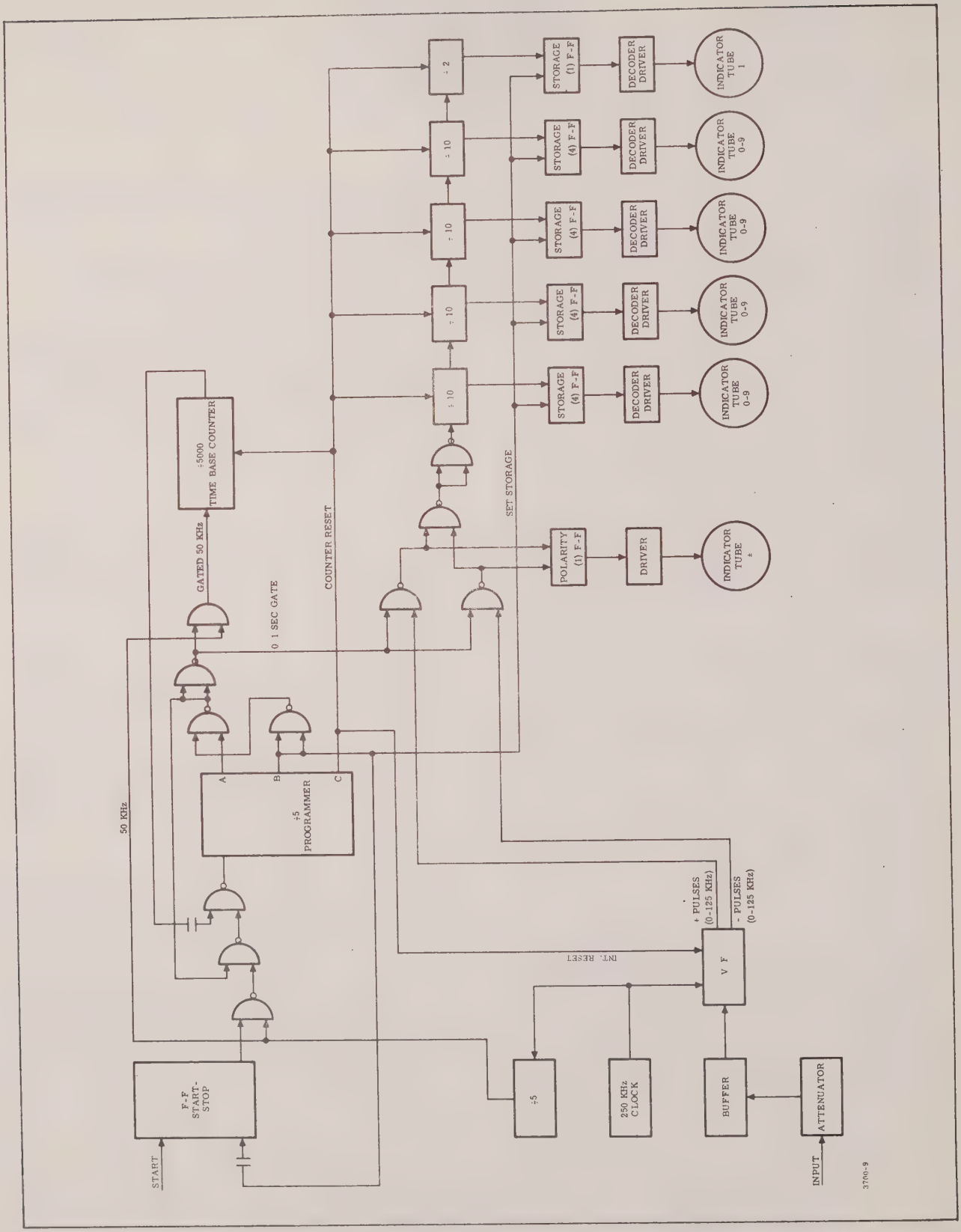
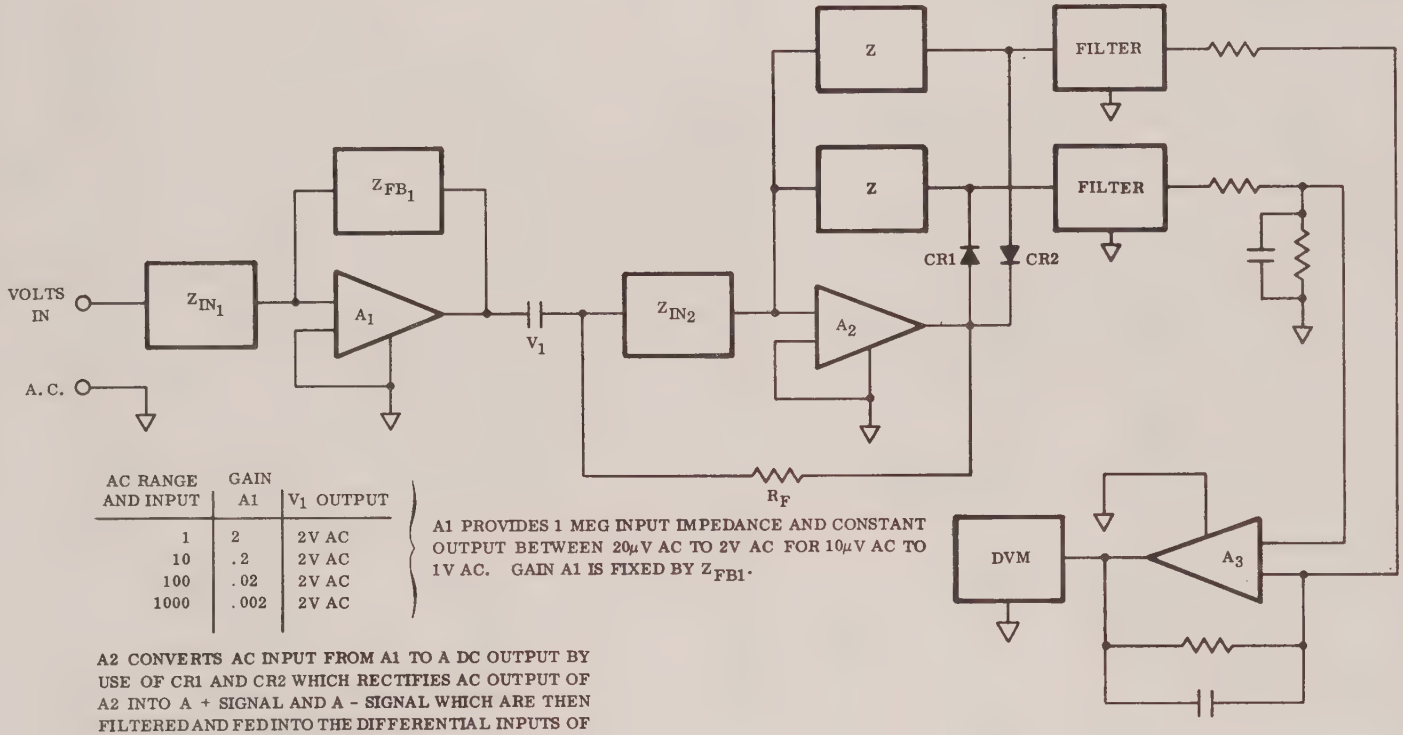


Figure 4-1. Block Diagram Series X-2 DVM



AC RANGE AND INPUT	GAIN A1	V_1 OUTPUT
1	2	2V AC
10	.2	2V AC
100	.02	2V AC
1000	.002	2V AC

A1 PROVIDES 1 MEG INPUT IMPEDANCE AND CONSTANT OUTPUT BETWEEN 20μV AC TO 2V AC FOR 10μV AC TO 1V AC. GAIN A1 IS FIXED BY Z_{FB1}.

A2 CONVERTS AC INPUT FROM A1 TO A DC OUTPUT BY USE OF CR1 AND CR2 WHICH RECTIFIES AC OUTPUT OF A2 INTO A + SIGNAL AND A - SIGNAL WHICH ARE THEN FILTERED AND FED INTO THE DIFFERENTIAL INPUTS OF A3. A3 PUTS AN OUTPUT IN THE RANGE OF THE DVM (10μV TO 10 VOLTS DC).

3600-26

Figure 4-2. Simplified Diagram AC Converter

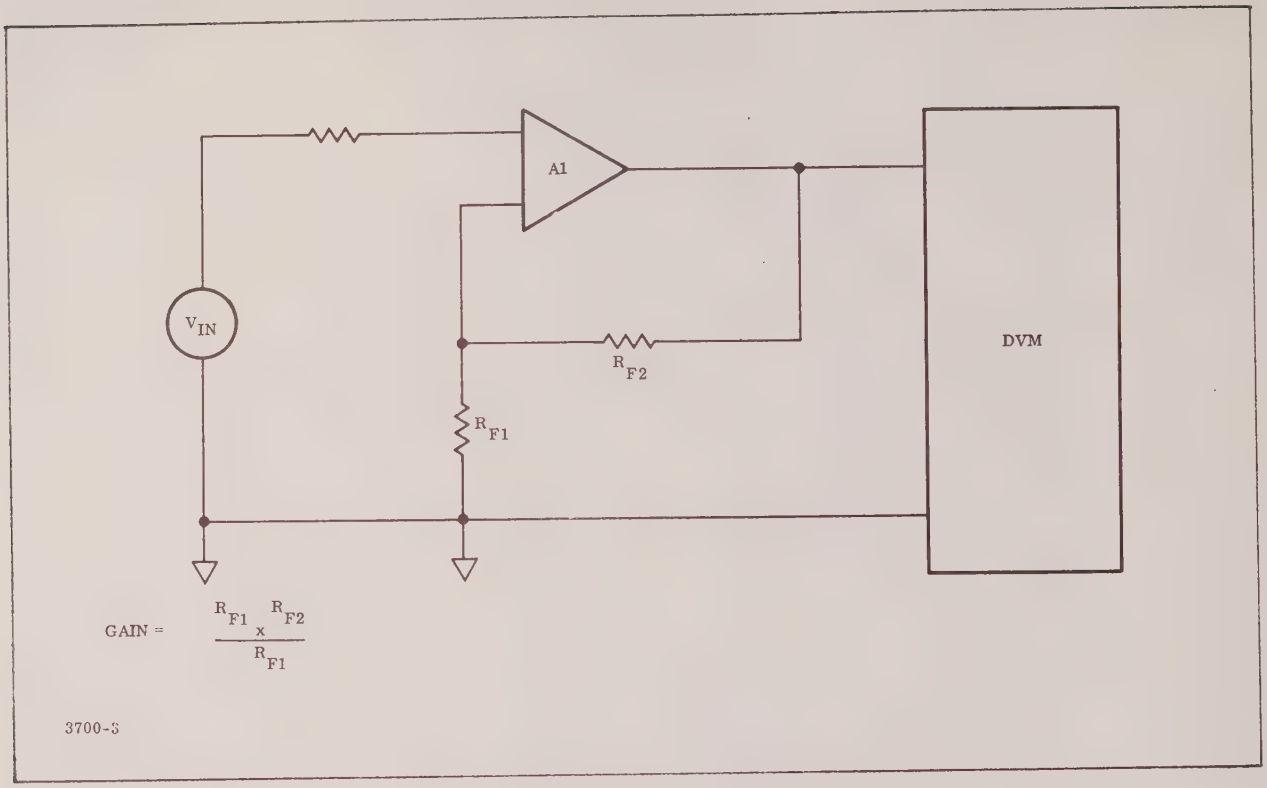
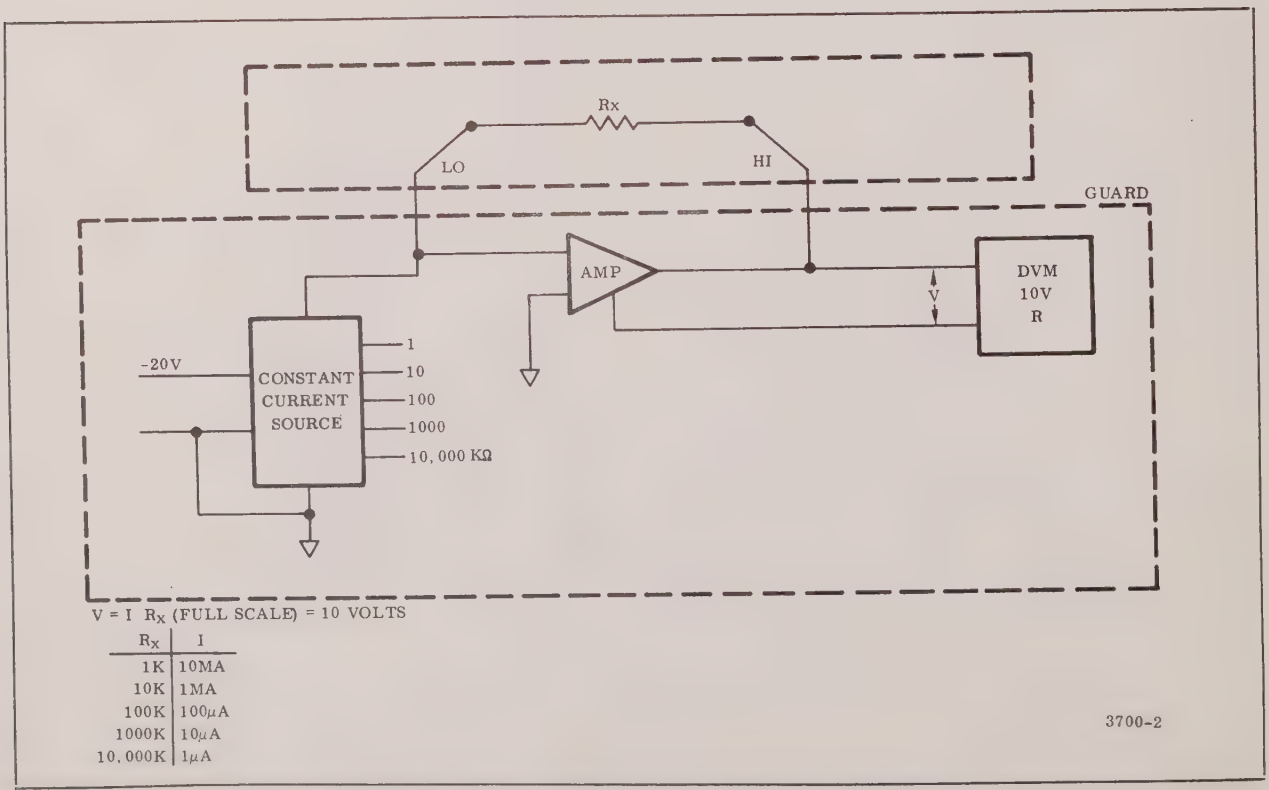


Figure 4-3. Simplified Diagram Pre-amplifier



R_X	I
1K	10MA
10K	1MA
100K	100μA
1000K	10μA
10,000K	1μA

Figure 4-4. Simplified Diagram Ohms Converter

TRUTH TABLES

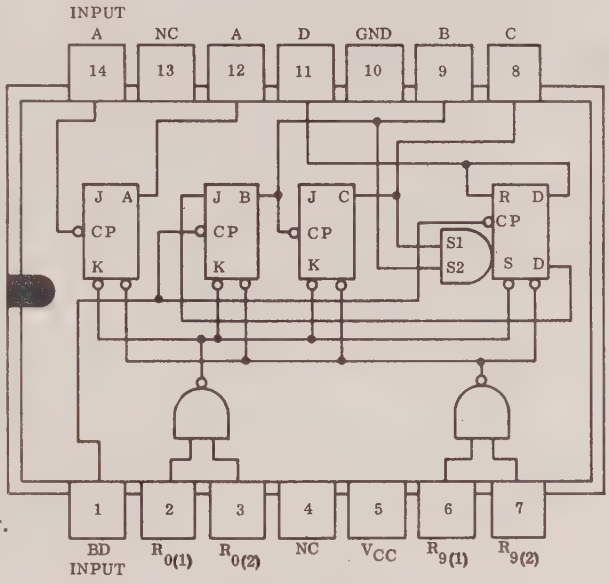
BCD COUNT SEQUENCE
(SEE NOTE 1)

COUNT	OUTPUT			
	D	C	B	A
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

RESET/COUNT (SEE NOTE 2)

RESET INPUTS				OUTPUT
$R_{0(1)}$	$R_{0(2)}$	$R_{9(1)}$	$R_{9(2)}$	D C B A
1	1	0	X	0000
1	1	X	0	0000
X	0	1	1	1001
0	X	1	1	1001
1	1	1	1	1001
X	0	X	0	COUNT
0	X	0	X	COUNT
0	X	X	0	COUNT
X	0	0	X	COUNT

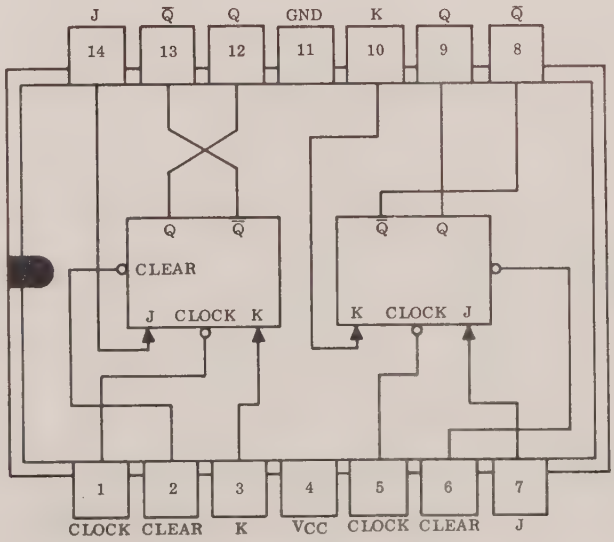
NOTES:
1. OUTPUT A CONNECTED TO INPUT BD FOR BCD COUNT.
2. X INDICATES THAT EITHER A LOGICAL 1 OR A LOGICAL 0 MAY BE PRESENT.



POSITIVE LOGIC
SEE TRUTH TABLES
NC–NO INTERNAL CONNECTION

3700-10

Figure 4-5. Type SN7490N Decade Counter



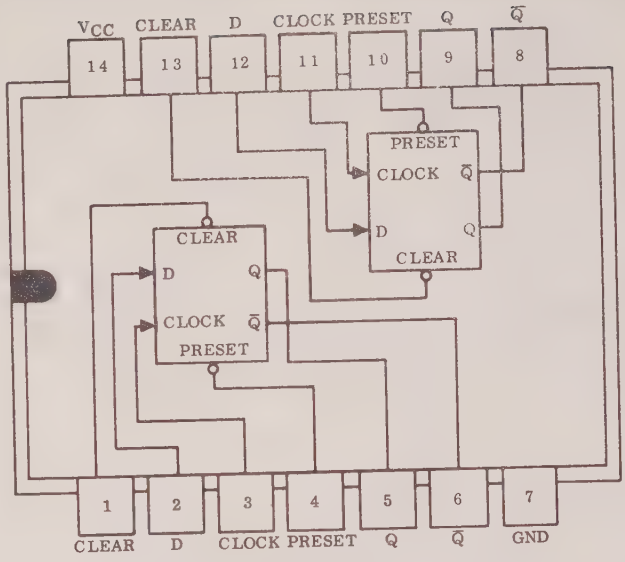
POSITIVE LOGIC
LOW INPUT TO CLEAR SETS Q TO LOGICAL 0
REGARDLESS OF CLOCK STATE.

3700-11

TRUTH TABLE (EACH FLIP-FLOP)		
t_n		$t_n + 1$
J	K	Q
0	0	Q_n
0	1	0
1	0	1
1	1	$\overline{Q}_n$

NOTES:
1. t_n = BIT TIME BEFORE CLOCK PULSE.
2. $t_n + 1$ = BIT TIME AFTER CLOCK PULSE.

Figure 4-6. Type SN7473N Dual J-K Master-Slave Flip-Flop



POSITIVE LOGIC

a. LOW INPUT TO CLEAR SETS Q TO LOGICAL 0.
b. LOW INPUT TO PRESET SETS Q TO LOGICAL 1.
c. CLEAR OR PRESET INPUTS DOMINATE REGARDLESS OF CLOCK AND D INPUTS.

3700-12

TRUTH TABLE (EACH FLIP-FLOP)

t_n	$t_n + 1$	
INPUT D	OUTPUT Q	OUTPUT $\bar{Q}$
0	0	1
1	1	0

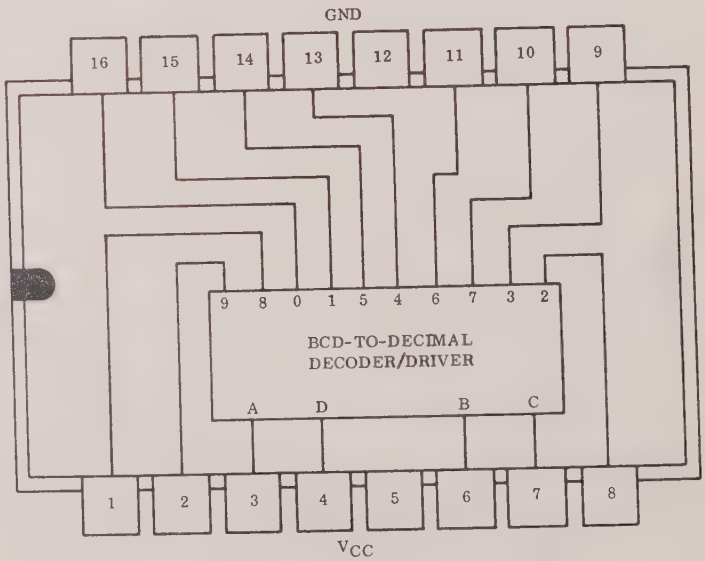
NOTES:
1. t_n = BIT TIME BEFORE CLOCK PULSE.
2. $t_n + 1$ = BIT TIME AFTER CLOCK PULSE.

Figure 4-7. Type SN7474N Dual D-Type Edge-Triggered Flip-Flop

TRUTH TABLE

INPUT				OUTPUT ON ‡
D	C	B	A	
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9

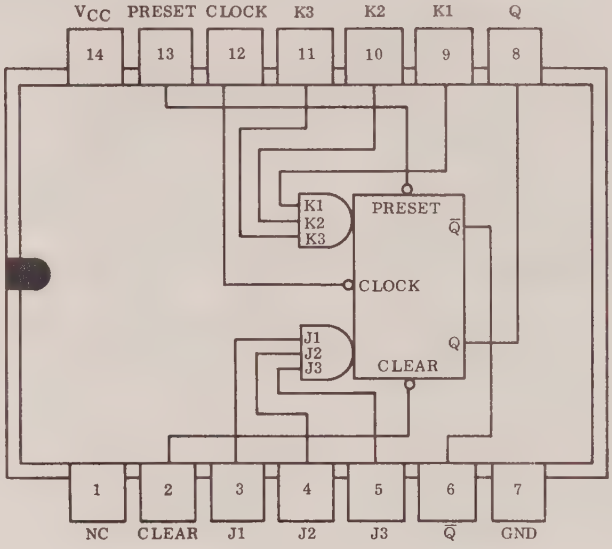
‡ ALL OTHER OUTPUTS ARE OFF.



3700-13

POSITIVE LOGIC
SEE TRUTH TABLE

Figure 4-8. Type SNX7441N BCD-to-Decimal Decoder/Driver



TRUTH TABLE		
t_n		$t_n + 1$
J	K	Q
0	0	Q_n
0	1	0
1	0	1
1	1	$\bar{Q}_n$

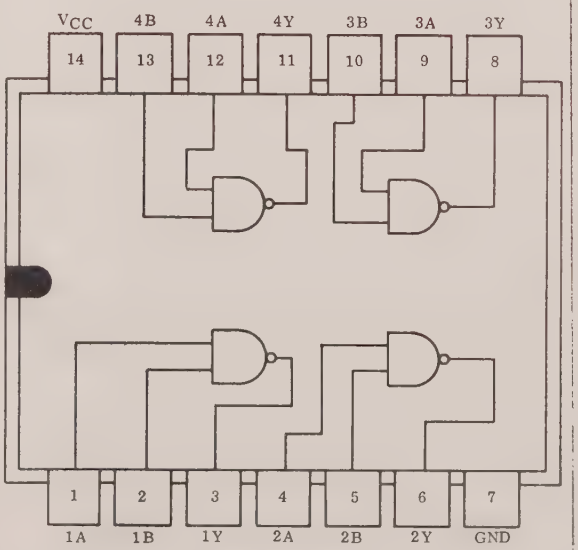
NOTES: 1. $J = J1 \cdot J2 \cdot J3$
2. $K = K1 \cdot K2 \cdot K3$
3. t_n = BIT TIME BEFORE CLOCK PULSE.
4. $t_n + 1$ = BIT TIME AFTER CLOCK PULSE.

POSITIVE LOGIC
LOW INPUT TO PRESET SETS Q TO LOGICAL 1
LOW INPUT TO CLEAR SETS Q TO LOGICAL 0

NC–NO INTERNAL CONNECTION.

3700-14

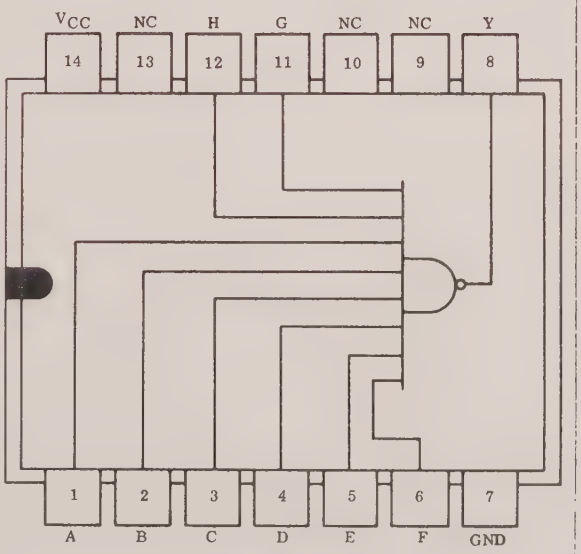
Figure 4-9. Type SN7470N JK Master-Slave Flip-Flop



POSITIVE LOGIC
$Y = \overline{AB}$

3700-15

Figure 4-10. Type SN7400N Quadruple 2-Input Positive Nand Gate



POSITIVE LOGIC
$Y = \overline{ABCDEFGH}$

3700-16 NC–NO INTERNAL CONNECTION

Figure 4-11. Type SN7430N 8-Input Positive Nand Gate

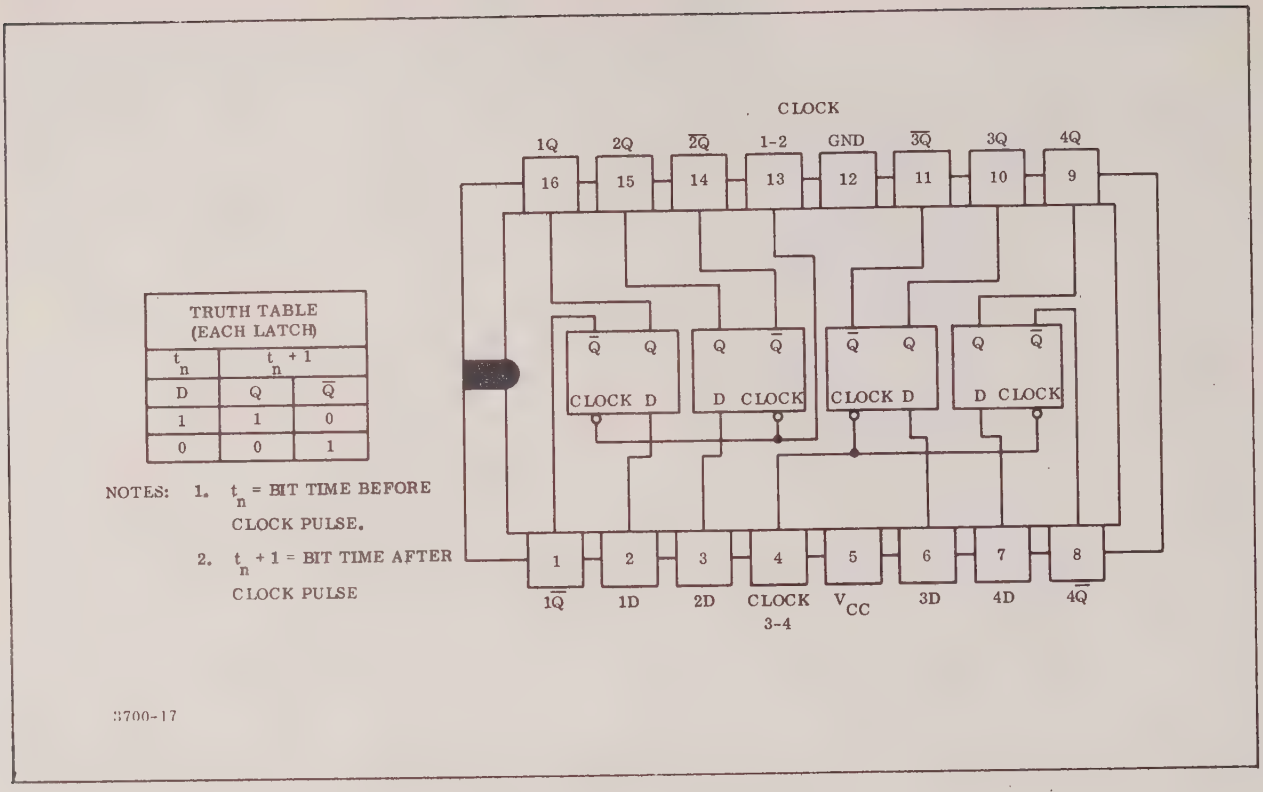


Figure 4-12. Type SN7475N Quadruple Bistable Latch

CHAPTER V

RECOMMENDED SPARE PARTS LIST

Part No.	Description	Qty.
37-30	Decade Assembly	1
37-36	Reference Assembly	1
37-39	Attenuator Assembly	1
37-69	Start-Stop Assembly*	1

*If instrument has auto ranging capability, substitute 37-33, Auto-Range and Start-Stop Assembly.

APPENDIX

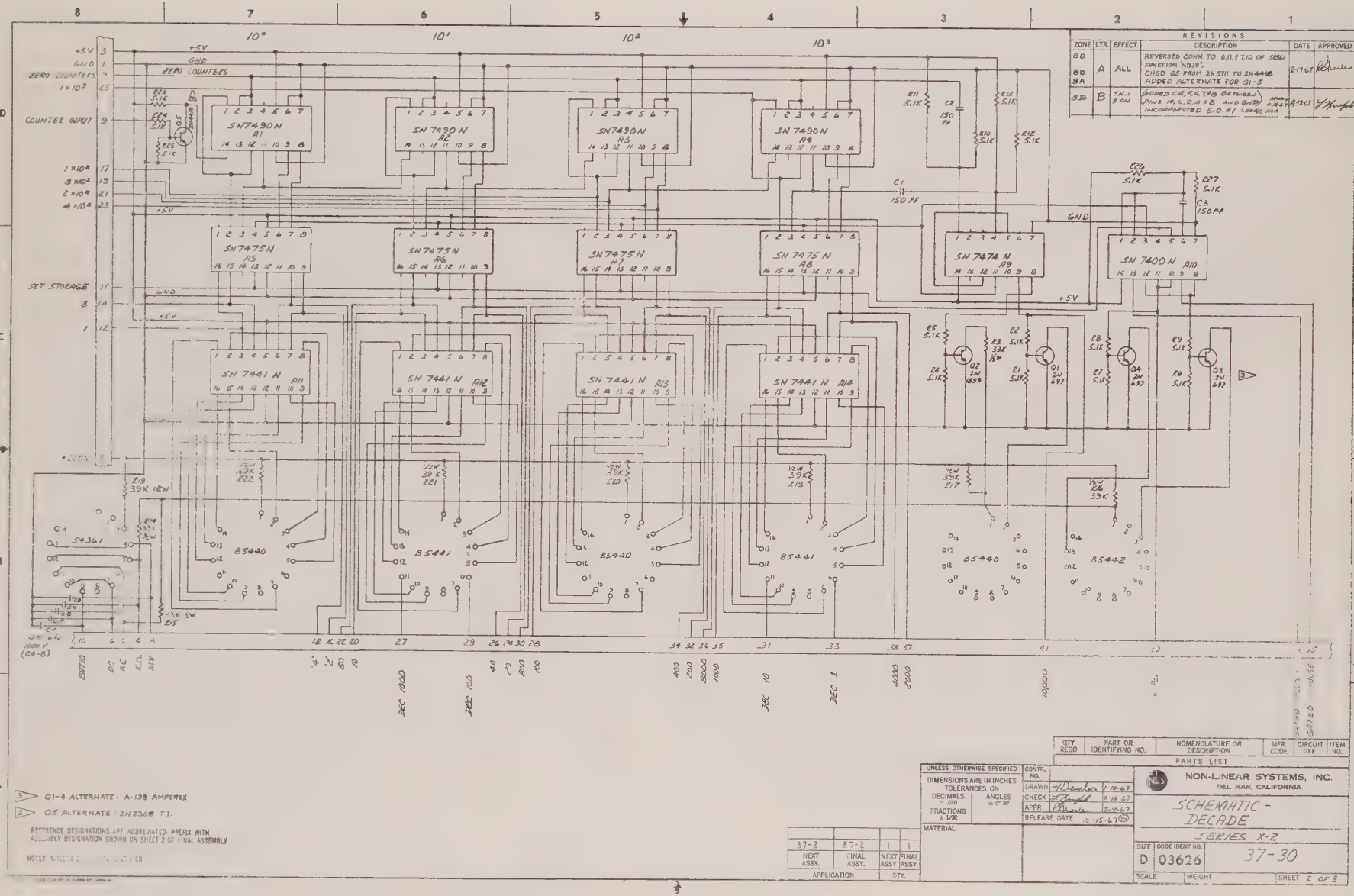
SHIPPING INSTRUCTIONS

Depending upon location, the choice of carrier will vary. Never ship an instrument to us without having received shipping instructions. If requested, an estimate of charges can be made before work begins.

Be certain to pack the instrument carefully; while an outer and inner box, separated by two or three inches of excelsior is desirable, the instrument can be placed into a single container provided it is so packed that it will not shift about. As with the double box method, use two or three inches of shock-absorbent packing materials. The instrument itself should be first wrapped in heavy paper so as to keep excelsior or other particles from entering the instrument's louvers. If the original shipping container is in good condition, it may be used.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it does not operate or is damaged, a claim should be made with the carrier. The claim agent should receive a full report of damage, and this report sent to Non-Linear Systems, Inc. After receiving such a report we will advise you of the disposition of the instrument and arrange for its repair or replacement. Be certain to include model and serial number when corresponding.



REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
8B 8D 8A	A	ALL	REVERSED CONN TO 6,11, (7,10 OF SB361 FUNCTION N713B", CHGD Q5 FROM 2N3711 TO 2N4418 ADDED ALTERNATE FOR Q1-5	2-17-67	
8B	B	3N.1 8 ON	(ADDED C4,5,6,7,8,9, BETWEEN PINS 14,6,2,4,8 AND GND) INCORPORATED E.O.#1	4-13-67	

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF	ITEM NO.

PARTS LIST

[3] Q1-4 ALTERNATE : A-139 AMPEREX

[2] Q5 ALTERNATE : 2N2368 T1.

REFERENCE DESIGNATIONS ARE ABBREVIATED PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY

NOTES UNLESS [illegible]

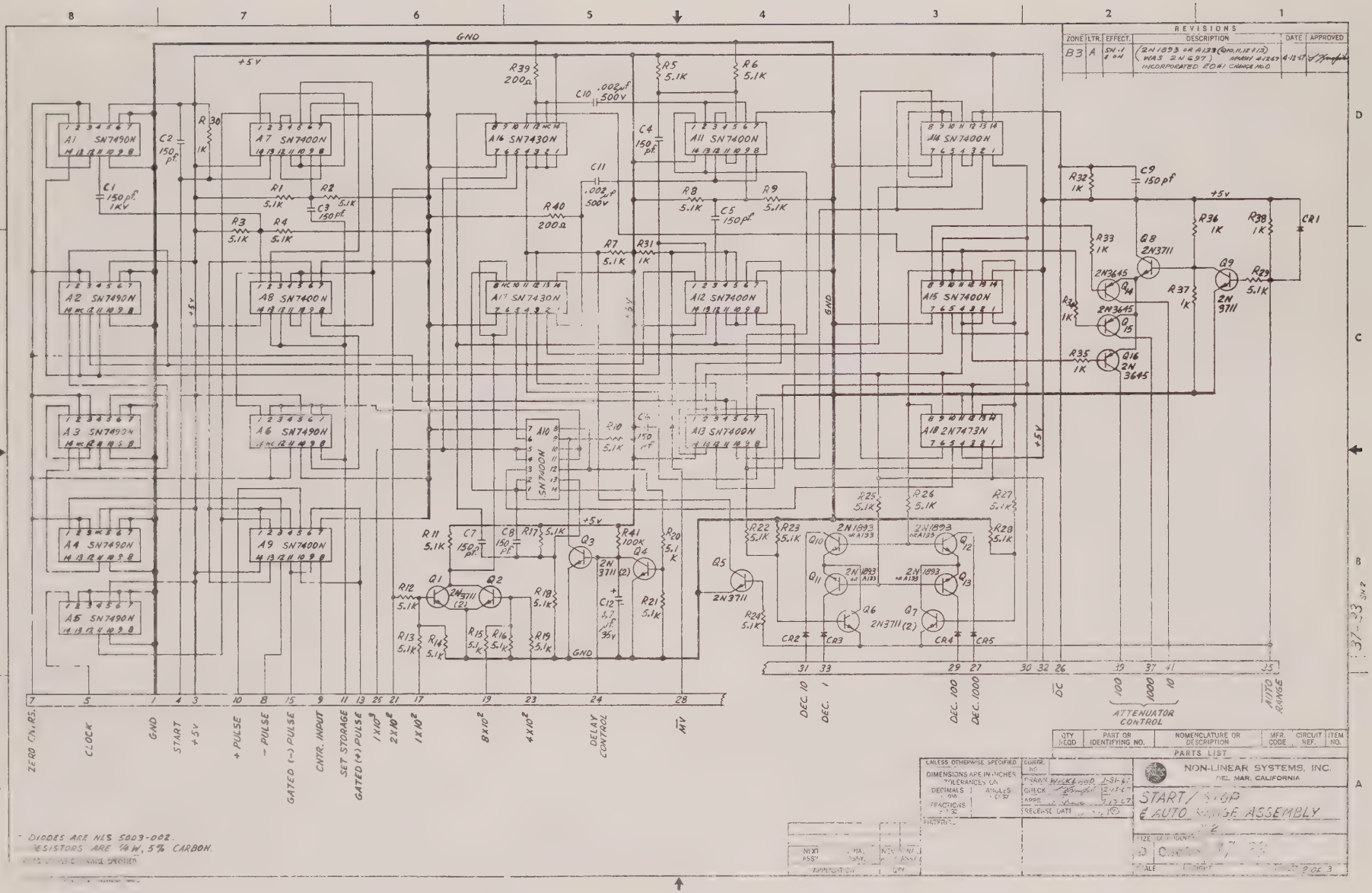
UNLESS OTHERWISE SPECIFIED	CONTR. NO.	
DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ± .010 ANGLES ± 0° 30' FRACTIONS ± 1/32	DRAWN	H. Dewitt 2-10-67
	CHECK	[illegible] 2-10-67
	APPR	[illegible] 2-10-67
	RELEASE DATE	2-15-67
MATERIAL		

37-2 NEXT ASSY.	37-2 FINAL ASSY.	1 NEXT ASSY	1 FINAL ASSY
APPLICATION		QTY.	

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC - DECADE
SERIES X-2

SIZE	CODE IDENT NO.	
D	03626	37-30
SCALE	WEIGHT	SHEET 2 OF 3



REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
B3	A	SN-1 & ON	(2N1893 OR A133 (Q10,11,12 & 13) WAS 2N697) INCORPORATED ECN1 CHANGE M.O.	4-13-67	

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS .XX ±.01
FRACTIONS ±1/32
ANGLES ±.5°

CONTR. NO.
DRAWN WICKLUND 1-31-67
CHECK 2-1-67
APPD.
RELEASE DATE

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

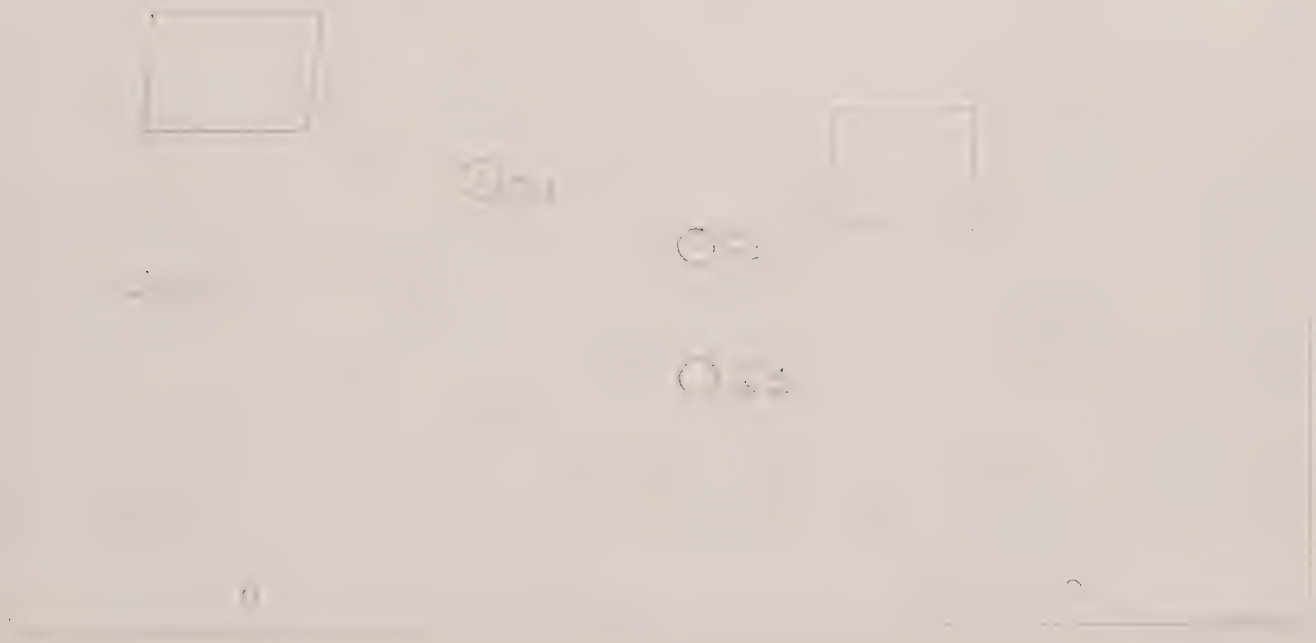
START / STOP & AUTO RANGE ASSEMBLY

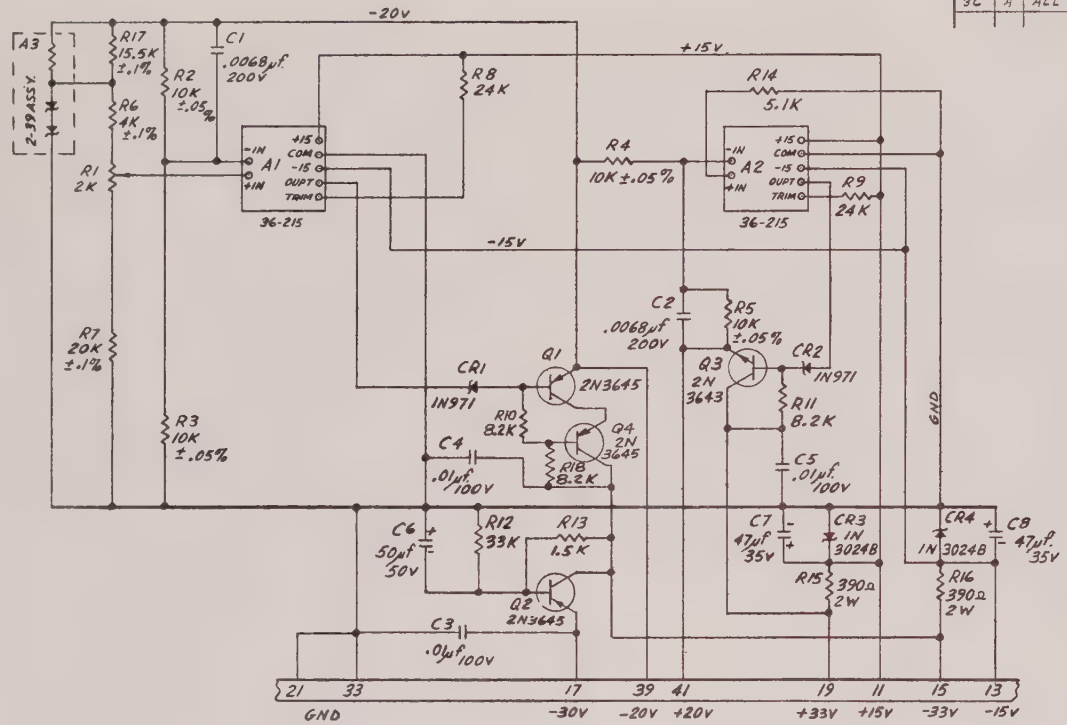
SIZE
SCALE
SHEET 2 OF 3

NEXT ASSY. USED ON
APPLICATION
QTY

- DIODES ARE NLS 5003-002.
- RESISTORS ARE ¼W, 5% CARBON.

37-33 SH 2





REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
3C	A	ALL	ADDED Q4 & R18 R.D.W.	2-23-67	2-25-67 RWJ

37-36 SH 2

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.

PARTS LIST

3. REFERENCE DESIGNATIONS ARE ABBREVIATED; PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY

2. RESISTORS R2 THRU R7 & R17 ARE NLS PW2016.

1. RESISTORS ARE 1/4 W, ±5%, CARBON.

NOTES: UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED	CONTR. NO.		
DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ± .010 ANGLES ± 0° 30' FRACTIONS ± 1/32	DRAWN	WICKLAND	2-1-67
	CHECK	[illegible]	2-16-67
	APPR	R. Johnson	2-16-67
	RELEASE DATE	2-16-67	

MATERIAL

37-2	37-2	1	1
NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
APPLICATION		QTY.	

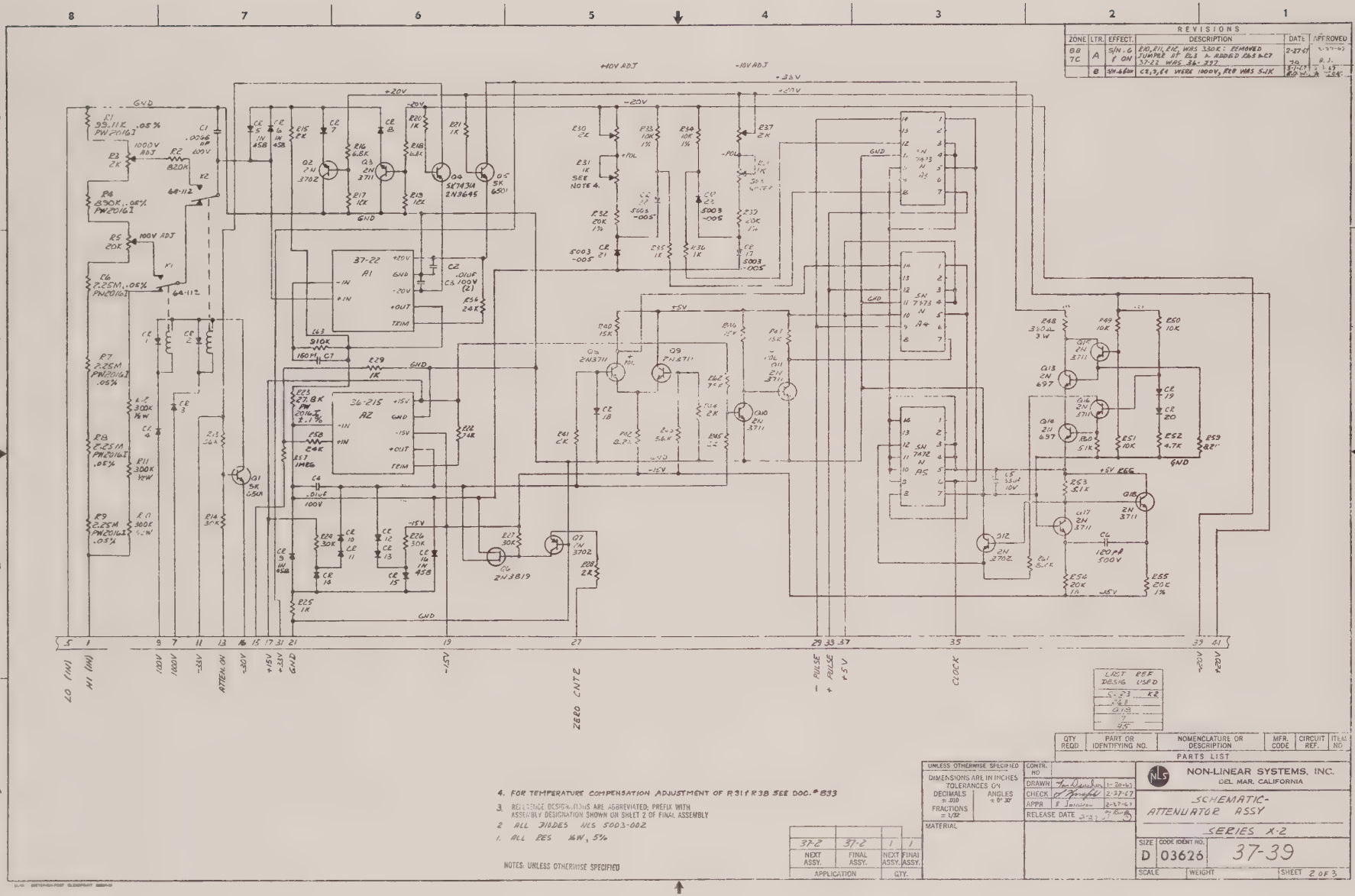
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

-SCHEMATIC-
REFERENCE ASSEMBLY
X2

SIZE	CODE IDENT NO.	
C	03626	37-36

SCALE | WEIGHT | SHEET 2 OF 3

E-98 DIETER-CHPOST CLEARPRINT 1000H-30



REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
8B 7C	A	S/N 6 & ON	E30, R31, E32, WAS 330K: REMOVED JUMPER AT E23 & ADDED E65 & C7 37-22 WAS 36-332	2-27-67	R.J.
	B	S/N 6 & ON	C8, 9, 14 WERE 1000V, R28 WAS 5.1K	3-7-67	R.J.

4. FOR TEMPERATURE COMPENSATION ADJUSTMENT OF R31 & R38 SEE DOC.# 833
3. REFERENCE DESIGNATIONS ARE ABBREVIATED; PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY
2. ALL DIODES NLS 5003-002
1. ALL RES ¼W, 5%

NOTES: UNLESS OTHERWISE SPECIFIED

LAST REF DESIG USED
S-23 K2
K2-3
Q-13
7
J5

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO

PARTS LIST

37-2 NEXT ASSY.	37-2 FINAL ASSY.	1 NEXT ASSY.	1 FINAL ASSY.
APPLICATION		QTY.	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
ANGLES ± 0° 30'
FRACTIONS ± 1/32
MATERIAL

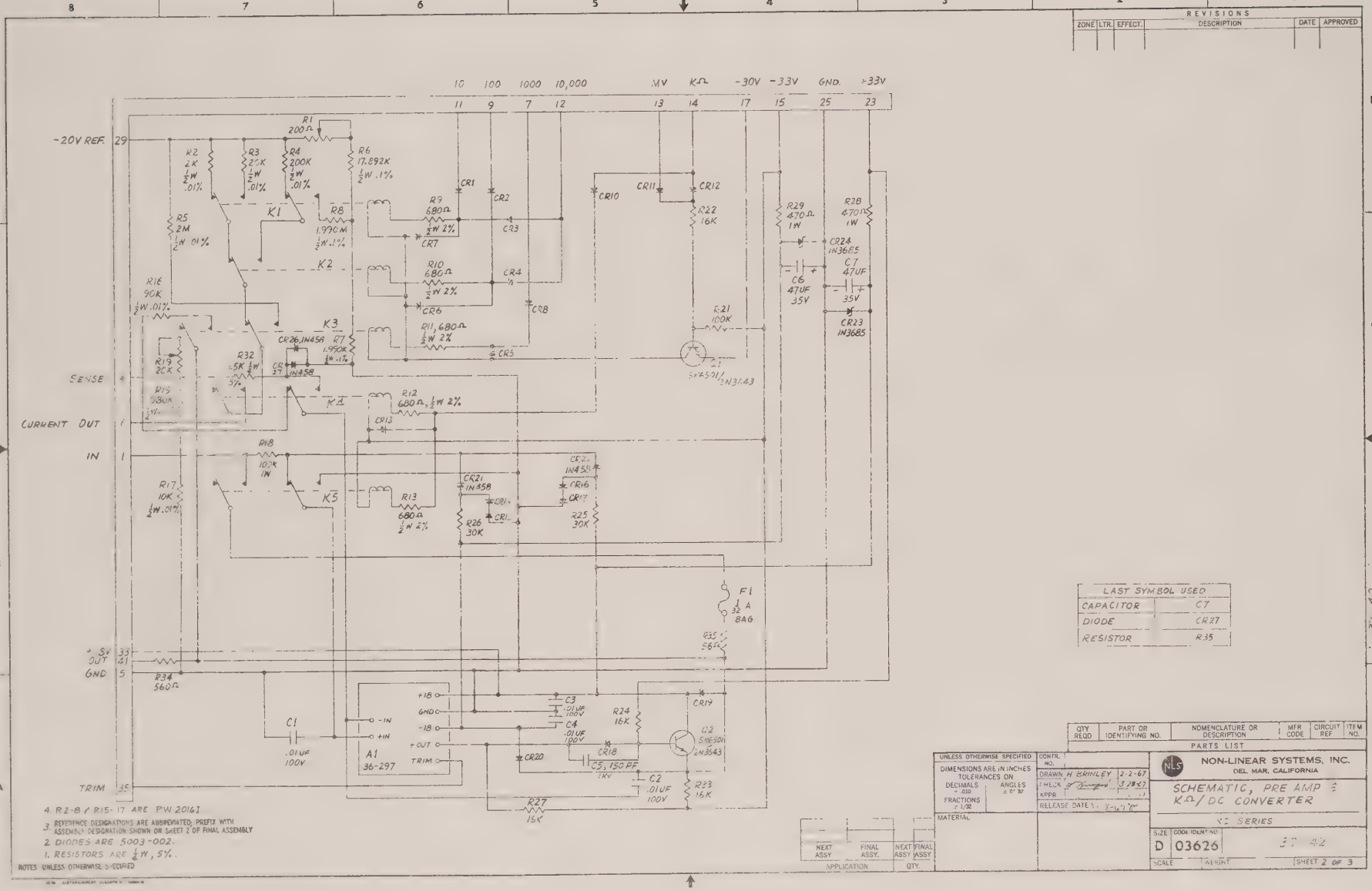
CONTR. NO
DRAWN Tom Dawson 1-20-67
CHECK A Knight 2-27-67
APPR R Johnson 2-27-67
RELEASE DATE 2-27-67 Tom Dawson

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC- ATTENUATOR ASSY

SERIES X-2

SIZE	CODE IDENT NO.	37-39
D	03626	
SCALE	WEIGHT	SHEET 2 OF 3



REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED

LAST SYMBOL USED	
CAPACITOR	C7
DIODE	CR27
RESISTOR	R35

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR CODE	CIRCUIT REF	ITEM NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
ANGLES ± 0° 30'
FRACTIONS ± 1/32
MATERIAL

CONTR. NO.
DRAWN H BRINLEY 2-2-67
CHECK 3-28-67
APPR
RELEASE DATE 3-16-67

NEXT ASSY | FINAL ASSY. | NEXT ASSY | FINAL ASSY
APPLICATION | QTY.

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC, PRE AMP ÷ KΩ/DC CONVERTER

X2 SERIES

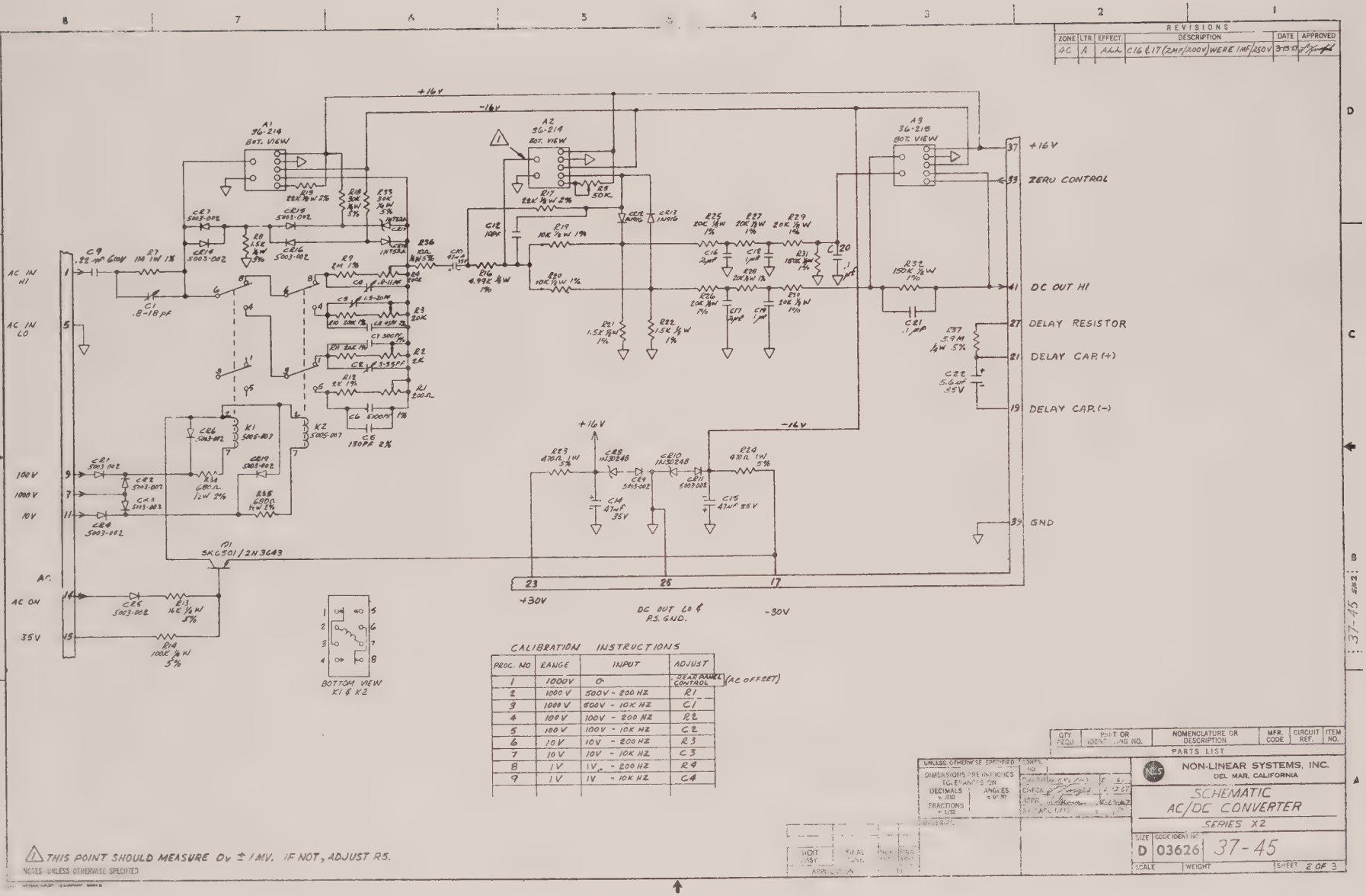
SIZE D | CODE IDENT NO. 03626 | 3T-42

SCALE | WEIGHT | SHEET 2 OF 3

4. R2-8 & R15-17 ARE PW 20161
3. REFERENCE DESIGNATIONS ARE ABBREVIATED. PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY
2. DIODES ARE 5003-002.
1. RESISTORS ARE ¼W, 5%.

NOTES UNLESS OTHERWISE SPECIFIED

3T-42 SH. 2



CALIBRATION INSTRUCTIONS

PROC. NO	RANGE	INPUT	ADJUST
1	1000V	0	REAR PANEL CONTROL (AC OFFSET)
2	1000 V	500V - 200 HZ	R1
3	1000 V	500V - 10K HZ	C1
4	100 V	100V - 200 HZ	R2
5	100 V	100V - 10K HZ	C2
6	10 V	10V - 200 HZ	R3
7	10 V	10V - 10K HZ	C3
8	1 V	1V - 200 HZ	R4
9	1 V	1V - 10K HZ	C4

⚠ THIS POINT SHOULD MEASURE 0v ± 1MV. IF NOT, ADJUST R5.

NOTES: UNLESS OTHERWISE SPECIFIED

ZONE	LTR	EFFECT	DESCRIPTION	DATE	APPROVED
AC	A	ALL	C16 & 17 (2MF/200V) WERE 1MF/250V	3-15-67	

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

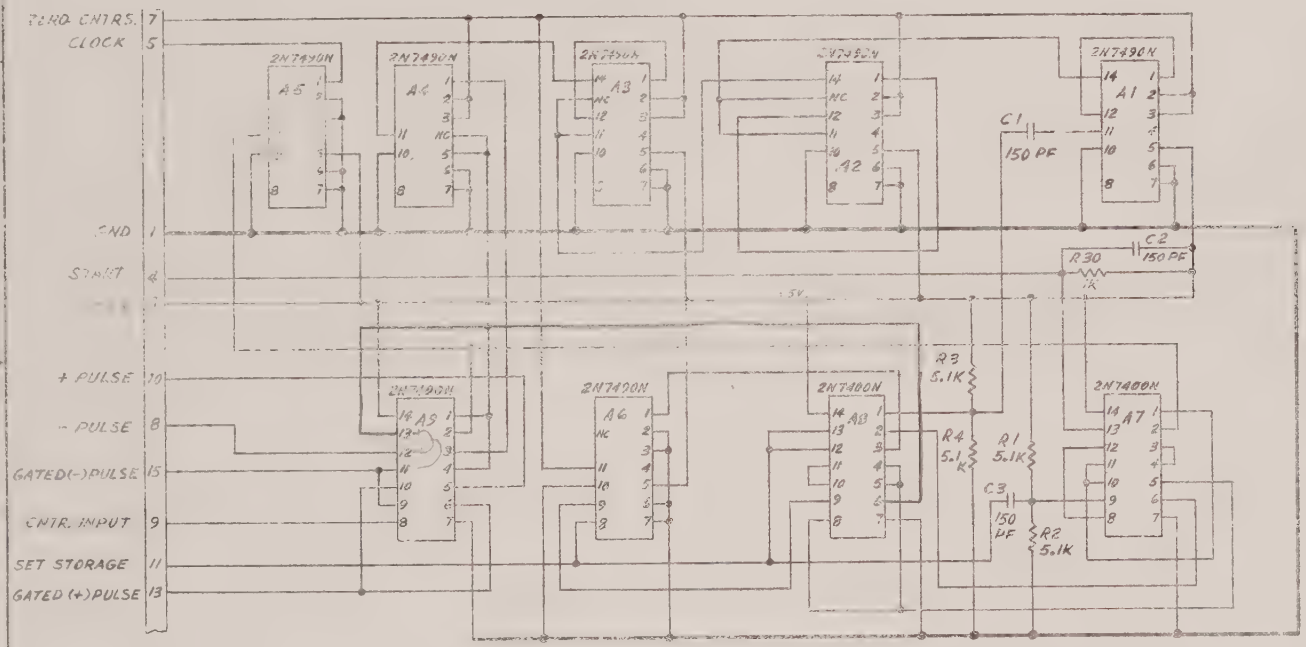
SCHEMATIC
AC/DC CONVERTER
SERIES X2

SIZE D | CODE IDENT NO. 03626 | 37-45

SCALE | WEIGHT | SHEET 2 OF 3

37-45 SH 2

REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
3B	A	ALL	CONNECTED A6-2,3,6&7 TO GND		



QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR CODE	CIRCUIT REF.	ITEM NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
FRACTIONS ± 1/32
ANGLES ± 0° 30'

CONTR NO

DRAWN	NICKLAND	2-3-67
CHECK	[illegible]	2-10-67
APPR	[illegible]	2-13-67
RELEASE DATE		2-13-67

MATERIAL

[illegible] SYSTEMS, INC.
DEL MAR, CALIFORNIA

START STOP ASS'Y.

SERIES X2

SIZE	CODE IDENT NO.	
C	03626	37-69

SCALE | WEIGHT | SHEET 2 OF 3

37-2 NEXT ASSY.	37-2 FINAL ASSY.	1 NEXT ASSY.	1 FINAL ASSY.
APPLICATION		QTY.	

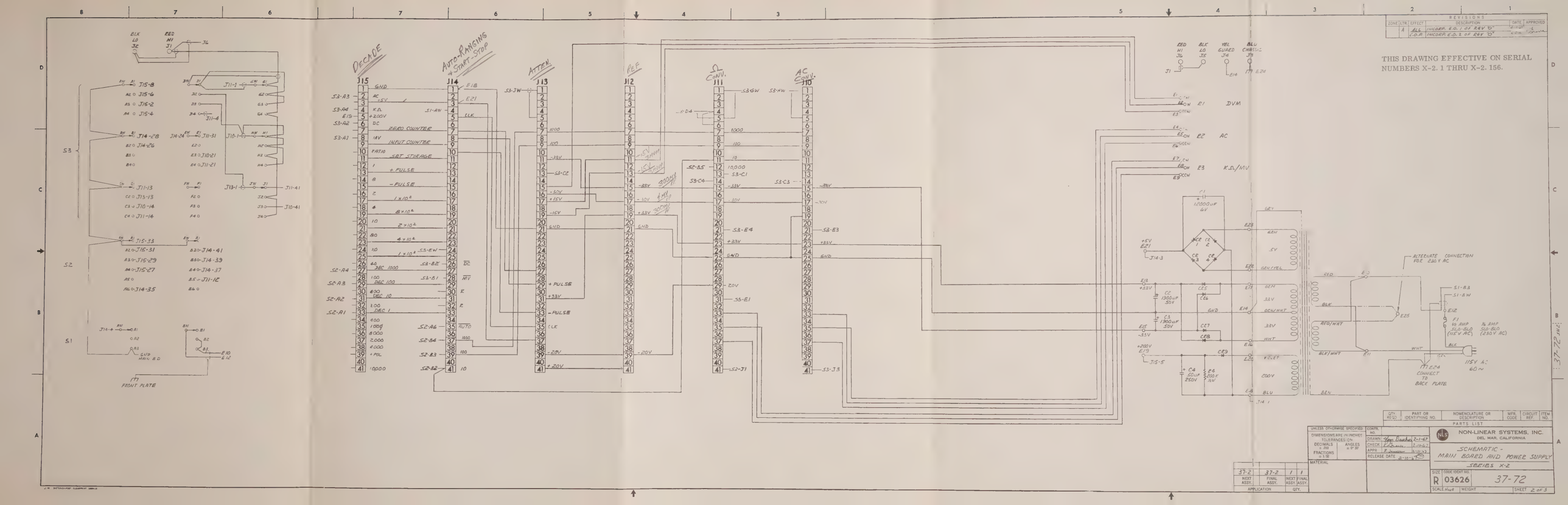
2 [illegible] ABBREVIATED; PREFIX WITH [illegible] ON SHEET 2 OF FINAL ASSEMBLY

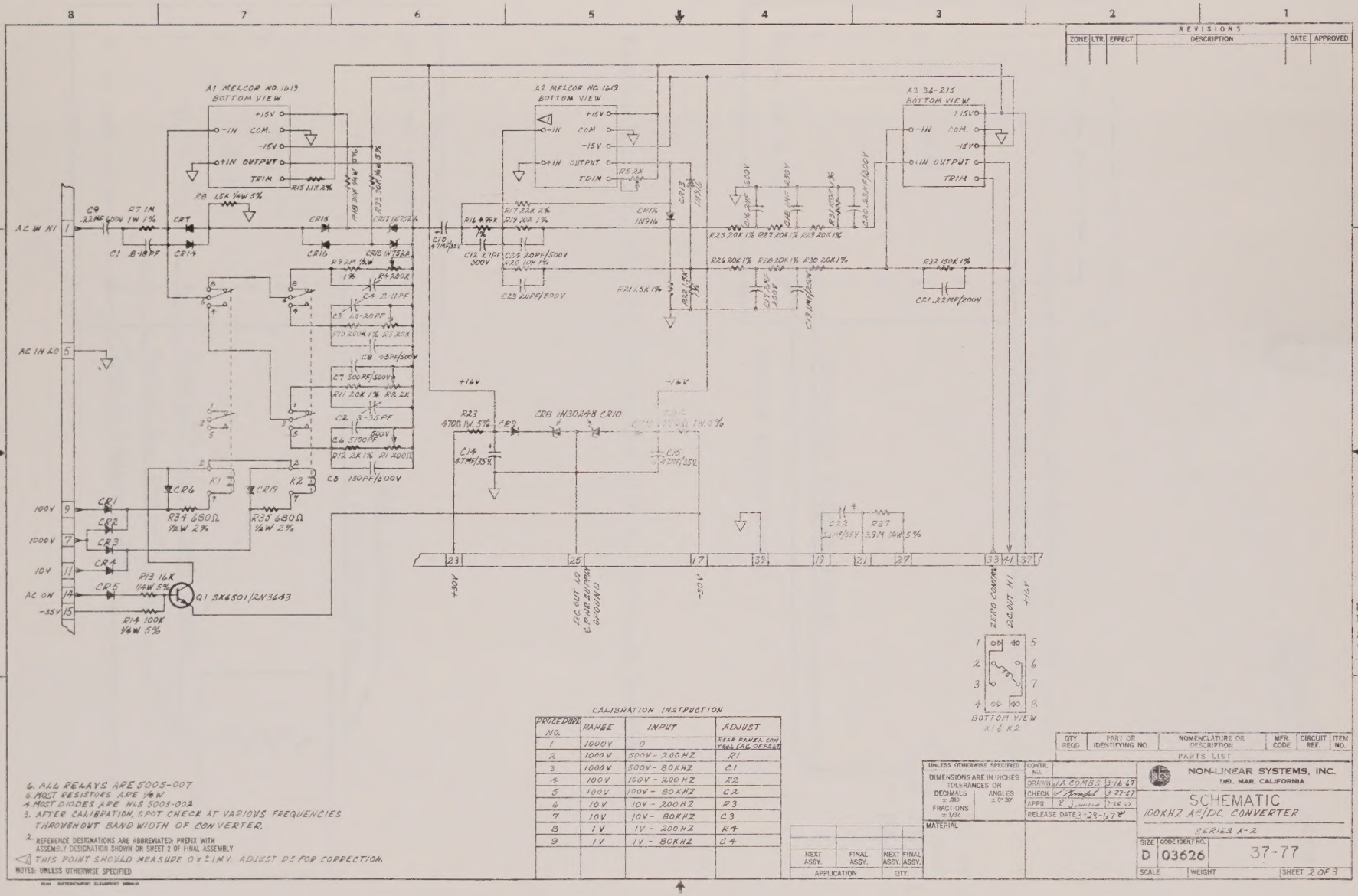
1. RESISTORS ARE 1/4 W, 5%, CARBON.

NOTES: UNLESS OTHERWISE SPECIFIED

[illegible] PETER DA PONT, DEL MAR, CA. 92014

37-69 SH 2


DECADE
AUTO-RANGING + START - STOP
ATTEN.
REF
S CONV.
AC CONV.
J15
J14
J13
J12
J11
J10
GND
AC
+5V
K Ω
INPUT COUNTER
ZERO COUNTER
RATIO
SET STORAGE
+ PULSE
- PULSE
DEC 1000
DEC 100
DEC 10
DEC 1
+200V
+33V
-33V
-20V
+15V
-15V
CLK
AUTO
DVM
AC
K Ω/MV
FRONT PLATE
MAIN B.D.
CONNECT TO BACK PLATE
ALTERNATE CONNECTION FOR 230 V AC
115 V A.C. 60 ~
REVISIONS
ZONE | LTR | EFFECT | DESCRIPTION | DATE | APPROVED
A | ALL | INCORP. E.O. 1 OF REV D | 2-20-67
C.O.R | INCORP. E.O. 2 OF REV D | 2-24-67
THIS DRAWING EFFECTIVE ON SERIAL NUMBERS X-2. 1 THRU X-2. 156.
PARTS LIST
QTY. REQD. | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MFR. CODE | CIRCUIT REF. | ITEM NO.
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ± .010 FRACTIONS ± 1/8 ANGLES ± 0° 30'
CONTR. NO.
DRAWN Tom Dunlap 2-1-67
CHECK C. Davis 2-10-67
APPD. F. Lindgren 2-13-67
RELEASE DATE 2-20-67
MATERIAL
37-2 NEXT ASSY. | 37-2 FINAL ASSY. | 1 1 NEXT FINAL ASSY. ASSY.
APPLICATION | QTY.
NLS NON-LINEAR SYSTEMS, INC. DEL MAR, CALIFORNIA
-SCHEMATIC- MAIN BOARD AND POWER SUPPLY
SERIES X-2
SIZE R | CODE IDENT NO. 03626 | 37-72
SCALE None | WEIGHT | SHEET 2 OF 3
37-72 REV



REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED

CALIBRATION INSTRUCTION

PROCEDURE NO.	RANGE	INPUT	ADJUST
			REAR PANEL CONTROL (AC OFFSET)
1	1000V	0	
2	1000V	500V - 200HZ	R1
3	1000V	500V - 80KHZ	C1
4	100V	100V - 200HZ	R2
5	100V	100V - 80KHZ	C2
6	10V	10V - 200HZ	R3
7	10V	10V - 80KHZ	C3
8	1V	1V - 200HZ	R4
9	1V	1V - 80KHZ	C4

6. ALL RELAYS ARE 5005-007
5. MOST RESISTORS ARE 1/6W
4. MOST DIODES ARE NLS 5003-002
3. AFTER CALIBRATION, SPOT CHECK AT VARIOUS FREQUENCIES THROUGHOUT BAND WIDTH OF CONVERTER.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED; PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY
1. THIS POINT SHOULD MEASURE 0V ± 1MV. ADJUST P3 FOR CORRECTION.

NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.

PARTS LIST

NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
APPLICATION		QTY.	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
ANGLES ± 0°30'
FRACTIONS ± 1/32
MATERIAL

CONTR. NO.
DRAWN J.A. COMBS 3/16-67
CHECK W. Kimball 3-27-67
APPR R. Johnson 7-28-67
RELEASE DATE 3-28-67

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC
100KHZ AC/DC CONVERTER
SERIES K-2

SIZE	CODE IDENT NO.	
D	03626	37-77
SCALE	WEIGHT	SHEET 2 OF 3

37-77

non linear
systems, inc.

DEL MAR, CALIFORNIA

www.manualsplus.com